CCME

Canadian Council
of Ministers
of the Environment

Le Conseil canadien
des ministres
de l'environnement

MANAGEMENT PLAN

FOR

Nitrogen Oxides (NO_x) AND Volatile Organic Compounds (VOCs)

Phase I

November 1990

CCME-EPC/TRE-31E

CCME

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of Ministers
of the Environment

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Canadian Council of Ministers of the Environment

MANAGEMENT PLAN
for
NITROGEN OXIDES (NO_x)
and
VOLATILE ORGANIC COMPOUNDS (VOCs)

PHASE I

NOVEMBER, 1990

FOREWORD

Nitrogen oxides (NO_x) and volatile organic compounds (VOCs) are precursor air pollutants that react in the presence of sunlight to form ground-level ozone, a major component of urban smog.

Above certain concentrations in the atmosphere, ozone causes adverse effects on human health, vegetation and materials.

In summer months, more than half of all Canadians are routinely exposed to ozone concentrations that are known to have adverse effects on health. Crop damage from ozone is substantial, with estimated losses in Ontario alone of up to $70,000,000 per year. There is not yet sufficient evidence of to determine loss of forest production or changes in forest ecosystems due to ozone, although it is known to cause damage to the foliage of forest species.

Recognizing the seriousness of the ground-level ozone problem in Canada, the Canadian Council of Ministers of the Environment (CCME) requested in October 1988, that a plan be developed for the further management of NO_x and VOCs. A three-phase plan was subsequently developed, with the aid of an extensive stakeholder consultation process, aimed at consistent attainment of the Canadian maximum acceptable air quality objective for ozone of 82 ppb by the year 2005. This document constitutes Phase I of that three-phase plan.

The NO_x/VOC Management Plan - Phase I contains both prevention and remedial emission reduction programs. The prevention and remedial programs will affect numerous mobile and stationary source sectors that emit NO_x and VOCs, ranging from automobiles through power plants and refineries to solvent use categories such as paints and coatings. They will also affect lifestyles to some degree by influencing product choice, consumer habits and transportation modes.

Implementation of the Phase I Plan is a shared responsbility of federal, provincial and municipal governments.

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LIST OF SYMBOLS AND ABBREVIATIONS

ADOM	Acid Deposition and Oxidants Model
BACTEA	Best Available Control Technology Economically Achievable
CCME	Canadian Council of Ministers of the Environment
CEPA	Canadian Environmental Protection Act
CFCs	Chlorofluorocarbons
CO_2	Carbon Dioxide
CSA	Canadian Standards Association
DSM	Demand Side Management
ECE	Economic Commission for Europe (United Nations)
EPA	Environmental Protection Agency (U.S.)
FPACAQ	Federal-Provincial Advisory Committee on Air Quality
GVRD	Greater Vancouver Regional District
g/BHP-hr	Grams per break horsepower - hour
g/mi	Grams per mile
HDV	Heavy Duty Vehicle
I & M	Inspection and Maintenance
KG/HA/YR	Kilogram per hectare per year
Km	Kilometer
KPa	Kilopascals
KT	Kilotonne
LDV	Light Duty Vehicle
LDT	Light Duty Truck
LFV	Lower Fraser Valley
LRTAP	Long Range Transport of Air Pollutants
MMBTU	Million BTU (British Thermal Unit)
NEB	National Energy Board
Ng/J	Nanograms per joule
NMHC	Non-Methane Hydrocarbons
NO	Nitric Oxide
NO_2	Nitrogen Dioxide
N_2O	Nitrous Oxide
NOx	Nitrogen Oxides
NSPS	New Source Performance Standard
O_3	Ozone
ppb	Parts per billion
ppmv	Parts per million in volume
ROM	Regional Oxidants Model
SAR	Southern Atlantic Region
SJA	Saint John Area
SO_2	Sulphur Dioxide
T/Yr	Tonnes per year
VOC	Volatile Organic Compound
WQC	Windsor-Quebec Corridor
ug/m^3	Micrograms per cubic meter

SUMMARY OF PLAN

In October, 1988, the Canadian Council of Ministers of the Environment (CCME) requested that a management plan be developed for the control of nitrogen oxides (NO_x) and volatile organic compounds (VOCs). The Plan was to be developed in consultation with interested stakeholders and delivered to CCME by October, 1990.

A comprehensive stakeholder consultation process was undertaken over the period August, 1989 to June, 1990. The process included review of a draft version of the "Phase I" management plan, which was publicly released on March 1, 1990. The Phase I Plan was subsequently finalized, taking into consideration the views of stakeholders, and submitted to CCME at its annual fall meeting in November, 1990.

The NO_x/VOC Management Plan - Phase I represents the first phase of a three-phase NO_x and VOC control program aimed at fully resolving ground-level ozone problems in Canada by the year 2005. Phase I is designed to put in place a strong prevention program nationally supplemented by a comprehensive set of remedial actions in the areas of Canada most affected by ground-level ozone. Interim (1995 and 2000) NO_x and VOC reduction targets will be established in federal/provincial agreements for the three ozone non-attainment areas. These targets will be based in part on remedial measures identified in the Phase I Plan and be the criteria for designing the Phase I regional remedial programs.

The Phase I interim emission reduction targets are not expected to be sufficiently stringent to result in full resolution of the ozone problem. Subsequent editions of the Plan will be prepared in 1994 (Phase II) and, if necessary, in 1997 (Phase III) to define the final NO_x and VOC emission targets for years 2000 and 2005, and the additional measures that will be taken to meet those targets. The final 2005 targets will be selected to ensure consistent attainment of the Canadian maximum acceptable air quality objective for ozone of 82 ppb in all areas of Canada by the year 2005. These future phases of the Plan will also take into account new information on environmental and health effects of ozone, the effectiveness of U.S. control programs in reducing the transboundary flows of pollutants into Canada, the NO_x and VOC emission reduction benefits that might result from related programs, such as federal and provincial programs for the control of toxics, acid rain and greenhouse gases, and other pertinent information.

Nature of Concern

The NO_x/VOC Management Plan has been developed in recognition of the fact that there are serious NO_x and VOC related health and environmental concerns in parts of Canada today. The most important of these is the current impact of elevated levels of ground-level ozone.

Ozone is a secondary pollutant, formed during photochemical reactions between NO_x and VOCs in the presence of sunlight. At concentration levels currently experienced in the most populated regions of Canada, ozone has been shown to adversely affect human health and to reduce the yield and vitality of crops and of forest ecosystems. Human health concerns include acute effects such as decreased lung function, cough and discomfort, as well as chronic effects such as premature aging of the lungs. Vegetation damage is usually in the form of foliar damage which affects growth and productivity.

In summer months, more than half of all Canadians are routinely exposed to ambient air ozone concentrations that are known to cause adverse health effects. These levels are often more than twice the Canadian "maximum acceptable" air quality objective for ozone. During severe ozone episodes, such as those that occurred in 1988, people in some major Canadian cities have been advised to limit outdoor physical activity or stay indoors. Crop damage in Ontario alone from elevated ozone levels throughout the summer growing season is estimated at up to $70,000,000 per year. Ozone is known to damage the foliage of forest species but there is no firm evidence on loss of production or changes in forest ecosystems in Canada due to ozone.

International Actions

Elevated ambient air ozone concentrations are recognized around the world as a serious health and environmental problem. Concerns stem from both the observed long term buildup of background ozone levels in the northern hemisphere, and the magnitude of short duration high concentration exposures during ozone "episodes" that occur regionally. Many nations are in the process of establishing agressive new ground-level ozone reduction programs.

Countries have also joined forces in setting some common targets for ozone reduction. Canada and 24 other nations signed an international protocol in 1988 committing nations to a freeze in NO_x emissions at the 1987 level, the application of best available technology economically achievable to new sources, and the establishment of further measures to solve NO_x-related environmental problems by 1996. Canada is now participating in the negotiation of a VOC protocol.

Ozone and its precursor pollutants, NO_x and VOCs, can be transported long distances in the atmosphere. While domestically produced NO_x and VOC emissions are an important contributor to Canadian ground-level ozone problems, in parts of central and eastern Canada ozone, NO_x and VOCs imported from the United States are the dominant factor in the problem.

Steps are being taken in the United States which should result in reduced transboundary flow of ozone, NO_x and VOCs into Canada over the next decade. The proposals for amending the U.S. Clean Air Act that are now being considered by the U.S. Congress call for significant reductions in emissions of both NO_x and VOCs by the year 2000. However, at this point the objective of the U.S. program is attainment of an ambient ground-level ozone concentration of 120 ppb, a level approximately 50 percent higher than the Canadian target ozone concentration of 82 ppb. Without U.S. control measures, at least in key border regions, beyond those currently planned, the 82 ppb Canadian objective will not be attained in areas of Canada that are highly affected by transboundary flow.

Efforts are being made to establish a transboundary air quality agreement with the United States which would focus first on sulphur dioxide, but under which ozone, NO_x and VOCs could eventually be included.

Purpose and Scope of the Plan

The NO_x/VOC Management Plan has been designed to address the two primary objectives laid down by CCME in October, 1988. These are that the Plan should:

1) solve our domestic NO_x and VOC related environmental problems;
2) meet our international obligations.

The focus of the Plan is on the reduction of ground-level ozone. Other concerns with NO_x and VOCs, such as direct toxic effects of some VOCs, are secondary considerations in the Plan. These concerns are being addressed under other programs. Direct toxic effects, for example, are being dealt with through the Priority Substance List of the Canadian Environmental Protection Act and various provincial programs for the control of toxic air pollutants.

The Plan has been developed with consideration of other related air pollution control programs, including the Canadian acid rain control program and anticipated future programs for the control of greenhouse gas emissions. It was recognized at the outset that in addition to emission source control measures, the energy conservation and lifestyle change initiatives which are likely to be a primary thrust of a greenhouse gas control program, would also be necessary elements of any NO_x and VOC management plan that would fully resolve our ground-level ozone problems.

Preparation of the Plan has been guided by the principles for allocating emission reductions that were developed through a comprehensive stakeholder consultation process. The principles include, for example, equity and fairness, the need to prevent future air quality problems as well as resolve existing ones, the avoidance of undue restriction on technological innovation and choice of emission reduction options, and the ability of control measures to solve more than one environmental problem. The complete set of principles is listed in the Plan.

Overview of Three - Phase Approach

The NO_x/VOC Management Plan-Phase I is the first phase of a three-phase program aimed at fully resolving ground-level ozone problems in Canada by 2005. The primary components of each of the three phases are as follows:

Phase I

1. The establishment of a strong prevention program nationally.

2. Interim (1995 and 2000) NO_x and VOC emission reduction targets in designated ozone non-attainment areas.

3. Studies and investigations to provide the base for establishing final emission caps for ozone non-attainment areas for the years 2000 and 2005.

Phase II (1994)

1. Establishment of final NO_x and VOC emission caps for designated ozone non-attainment areas for the years 2000 and 2005.

2. Indentification of additional remedial measures for ozone non-attainment areas and, if appropriate, extension or tightening of the prevention program, to achieve the caps.

Phase III (1997)

1. Final adjustment to the ozone non-attainment area caps and emission reduction programs.

Description of the Phase I Plan

Each of the three primary components of the Phase I Plan are described below.

1. National Prevention Program

The national prevention program consists of a combination of new source performance standards based on best available technology economically achievable, measures to control VOC emissions from products containing solvents, energy conservation and efficiency measures, and public education.

A starting menu of 31 specific initiatives is defined for the Phase I prevention program, including schedules and identification of jurisdictions responsible for developing and implementing each initiative. These initiatives are two types:

1) those that would be implemented by the federal government, such as emission limits for mobile sources, energy efficiency standards for equipment and appliances, and product formulation and

2) those that would be developed nationally through federal-provincial cooperative programs but implemented by provinces such as new source performance standards for stationary sources of NOx and VOCs.

The 31 specific initatives represent the "base" prevention program. It is recognized that there may be other sequencing of control measure development and implementation, other combinations of initiatives, or other methodologies for implementation that would achieve equivalent or better ozone control and perhaps offer advantages in terms of cost effectiveness or preference by implementing jurisdictions. It is also recognized that some of the identified measures are likely to be included in other control programs making their inclusion in this Plan redundant. For example, federal and provincial programs for the control of greenhouse gases are likely to include more agressive energy conservation and efficiency measures than those identified in the Phase I Plan. If the geographic application and timing of the energy conservation and efficiency measures being implemented for greenhouse gas reduction is such that they will reduce ground-level ozone by amounts equivalent to the reductions expected from the measures identified in this Plan, then their application could revert totally to the greenhouse gas programs.

The Phase I Plan provides for substitution of "environmentally equivalent" measures to those specified in the base prevention program. The criteria for determining environmental equivalency are discussed further in Chapter IX, Plan Implementation.

2. Interim (1995 and 2000) Emission Reduction Targets for Ozone Non-Attainment Areas

In subsequent phases of the NO_x/VOC Management Plan, final NO_x and VOC emission caps will be set for the years 2000 and 2005. The 2005 caps will be selected to provide consistent attainment of the 82 ppb ozone objective in all parts of Canada. However, the information currently available on emissions, cause and effect relationships, effectiveness of U.S. control programs, and means available to further reduce emissions beyond the levels identified in Phase I is inadequate for setting final emission caps at this time. Consequently, only interim emission reduction targets will be negotiated as part of the Phase 1 Plan.

Three regions are designated ozone non-attainment areas for the purpose of establishing interim emission targets for the Phase I Plan. These areas are as follows:

- Lower Fraser Valley
- Windsor-Quebec Corridor
    - Ontario Portion
    - Quebec Portion
- Southern Atlantic Region
    - Saint John Area

The boundaries for the three designated ozone non-attainment areas are as described and as used in estimating emissions for these areas in Chapter V, Regional Analysis of Emission Reduction Requirements.

It is recommended that the interim targets be in the form of percentage reductions in annual emissions of NO_x and VOCs from a specified base year. Uncertainties in the available emission data perclude the establishment of actual reduction tonnages at this time, and the refinement of spatial and temporal scales that will be needed in setting final emission caps.

The interim emission reduction targets will be negotiated between the federal government and the jurisdiction having authority for each designated non-attainment area, and will be contained in federal/provincial agreements. They will be achieved by a combination of emission reductions as a result of the national prevention program and the remedial programs to be applied in the non-attainment areas. These remedial programs will be determined by the jurisdictions responsible for the designated non-attainment areas. However, to assist in identifying potential emission reduction options, to provide guidance in setting the interim targets, and to provide a bases for estimating emission reduction potential and costs, an illustrative Phase I NO_x and VOC control program for ozone non-attainment areas has been developed. This illustrative regional reduction program consists of 27 initiatives for reducing NO_x and VOC emissions, ranging from emission control retrofit on existing emission sources to improved urban transportation management and ozone episode management programs. Responsible jurisdictions may wish to draw upon this illustrative program in establishing the remedial programs that they will be implementing to reach the 1995 and 2000 target reductions. Once responsible jurisdictions have identified their starting or "base" remedial programs, these, like the base prevention program, could also be modified throughout the Phase I implementation period to account for new information and changing circumstances, so long as the interim emission reduction targets are met.

The interim annual percentage reduction targets will provide adequate guidance for this first round of emission reductions, provided some fundamental characteristics of ozone episodes and emission variability are taken into account in selecting the measures that will be taken to meet the targets. Particular emphasis should be placed on measures that will reduce summer daytime emissions as well as annual emissions.

It is recommended that the final emission caps for non-attainment areas for 2000 and 2005, to be set in the Phase II Plan in 1994, be in the form of total kilotonnes of NO_x and VOC emissions and have refined spatial and temporal dimensions from those used for the interim reduction targets. Annual targets alone are not appropriate in the long term for managing ozone, which is of most concern during short duration (hours or days) episodic events in summer. Also, in most cases, the areas delineated as non-attainment areas for the interim targets are too large for effective ozone management. In essence the time and spatial dimensions of the caps must be matched to the time and spatial dimensions of the problem.

The final 2000 and 2005 emission caps will probably consist of a two tier cap system for ozone non-attainment areas:

- a T/day limit (year round or variable by season, with emphasis on summer)
- a T/year limit

Areas other than the three current ozone non-attainment areas, such as airsheds around the large urban centres across the country, may also be designated non-attainment areas in the Phase II Plan. This will depend on how effective the Phase I prevention program is in reducing ozone peaks in areas now considered marginal with respect to ozone attainment (i.e., a limited number of exceedances of the 82 ppb objective now occur regularly each year).

3. Studies and Investigations

Additional information is needed in many areas before final NO_x and VOC emission caps can be set for ozone non-attainment areas. For example, the spatial and temporal distribution of emissions from some mobile source categories is not adequately defined. Among these categories are off-road diesel engines, heavy duty vehicles, marine and aircraft. Emission estimates for some mobile and stationary source categories are expected to require significant adjustment over the next year or two as better information is gathered. For example, VOC emissions from motor vehicles are thought to be underestimated by a factor of 2 or 3, and VOC emissions from solvent use sectors may require substantial adjustment when more information on the current level of emission control in these sectors is obtained. Also required is improved knowledge of cause and effect relationships, effectiveness of U.S. control programs in reducing transboundary emission flow, and effectiveness of related federal and provincial programs in reducing NO_x and VOC emissions.

Twenty four (24) study initiatives are outlined as part of the Phase I Plan. These were selected to generate the additional information needed to set final emission caps, design additional emission control programs and track progress towards the interim targets.

The 31 base prevention program initiatives and the 27 illustrative non-attainment area remedial initiatives under the Phase I Plan are summarized in Table A and B, which deal with NO_x and VOCs respectively. For both the prevention and remedial programs, initiatives are divided into three categories:

- energy conservation and product control;
- consumer choice and lifestyle; and
- source control

Studies and investigations for Phase II of the Plan are summarized in Table C.

The initiatives have been designed on the premise that both NO_x and VOC reductions are needed to resolve and prevent ground-level ozone problems in Canada. Control of both NO_x and VOCs is important for reducing peak ozone levels in urban areas. In rural areas, the reaction for ozone formation is usually NO_x limited, requiring that NO_x levels be reduced if reductions in ground-level ozone concentrations are to be achieved.

TABLE A NO_x/VOC MANAGEMENT PLAN - PHASE I: NO_x REDUCTION INITIATIVES

Initiative		Control Instrument			Reference Pages in Plan
		Type	Delivery Date	Effective Date	
(a) NATIONAL PREVENTION PROGRAM					
Energy Conservation and Product Control					
N101	Power utility DSM	DSM Plans	31 Dec. '92	1993-2005	68, 82
N102	Energy efficiency in equipment, appliances	Performance Stds.	31 Dec. '94	1994	68, 84
N103	Energy efficiency in industry	Performance Stds.	92/93/93/95	1993-1996	68, 85
N104	Energy audits by industry	Audit Plans	31 Dec. '91	1992	68, 86
N105	Energy efficiency in buildings	CSA Standards	31 Dec. '93	1994	68, 86
Consumer Choice and Lifestyle					
N201	Public Education - Driving/Alt. Transport	Public Ed. Campaign	91-99	1991-1999	68, 87
N202	Public Education - Energy Conservation	Public Ed. Campaign	91-99	1991-1999	69, 87
Source Control					
N301	Light Duty Veh./Light Duty Truck NO_x limit	Federal Regulation	91/92	1994-1996	69, 87
N302	Heavy duty vehicle NO_x limits	Voluntary/Fed. Reg.	91/93	1991/1994	69, 88
N303	Const. diesel engine NO_x limits	Federal Regulation	31 Dec. '95	1998	69, 90
N304	Cap on rail transport NO_x	Reporting Schedule	31 Dec. '91	1992	69, 91
N305	NSPS - Power plants	CEPA Guideline	91-94	1995/2000	69, 92
N306	NSPS - Industrial Boilers	CCME Guideline	31 Dec. '91	1994	69, 93
N307	NSPS - Gas Turbines	CCME Guideline	30 June '92	1994	69, 94
N308	NSPS - Compressor Engines	CCME Guideline	31 Dec. '91	1993	70, 95
(b) ILLUSTRATIVE REGIONAL REMEDIAL PROGRAM (See Plan for Regional Application)					
Energy Conservation and Product Control					
N401	Urban Transportation Management	Management Plans	92-94		70, 96
Consumer Choice and Lifestyle					
N501	Ozone Episode Management	Mun. Plans/Criteria	31 Mar. '93	1993	70, 97
N502	Highway speed reduction	Provincial Programs	31 Dec. '92	1993	70, 98
N503	Public Education-Highway speeds	Prov. Pub. Ed. Campaign	92-99	1993-1999	70, 99
Source Control					
N601	Motor Vehicle Inspection & Maintenance (I&M)	Provincial Programs	31 Dec. '93	1994	71, 99
N602	New and Existing Power Plants	Prov. Limits/Schedules	31 Dec. '92	1994/1997	71, 100
N603	Retrofit - Existing Industrial Boilers	Prov. Limits/Schedules	31 Dec. '93	1997	71, 102
N604	New and Existing Iron & Steel Mills	Prov. Limits/Schedules	31 Dec. '93	1995/1997	71, 103
N605	Retrofit - Existing Refinery Processes	CCME Guideline	31 Dec. '93	1997	71, 104

TABLE B NO_x/VOC MANAGEMENT PLAN - PHASE I: VOC REDUCTION INITIATIVES

Initiative		Control Instrument			Reference Page in Plan
		Type	Delivery Date	Effective Date	
(a) NATIONAL PREVENTION PROGRAM					
Energy Conservation and Product Control					
V101	Emission Reduction - Surface Coating	CCME Reduction Plan	31 Dec. '93	1997	72, 105
V102	Emission Reduction - Adhesives & Sealants	CCME Guideline	31 Dec. '93	1997	72, 106
V103	Emission Reduction - Consumer Products	CCME Reduction Plan	30 June '94	1997	72, 106
V104	Emission Reduction - General Solvent Use	CCME Reduction Plan	31 Dec. '94	2000	72, 107
Consumer Choice and Lifestyle					
V201	Public Education - Driving/Alt. Transport	Public Ed. Campaign	91-99	1991-1999	72, 108
V202	Public Education - Solvent Use/Recycle	Public Ed. Campaign	91-99	1991-1999	72, 108
Source Control					
V301	Light Duty Veh./Light Duty Truck VOC Limit	Federal Regulation	91/92	1994-1996	73, 109
V302	NSPS - Volatile Liquid Storage Tanks	CCME Guideline	31 Dec. '91	1993	73, 110
V303	NSPS - Chemical Plant Processes	CCME Guideline	31 Dec. '92	1994	73, 110
V304	NSPS - Chemical Plant Fugitive Emissions	CCME Code	31 Dec. '91	1993	73, 111
V305	NSPS - Plastics Processing	CCME Guideline	30 June '93	1995	73, 112
V306	NSPS - Pulp & Paper Sulphate Process	CCME Guideline	31 Dec. '92	1994	73, 113
V307	NSPS - Comm/Ind. Coating Application	CCME Code/Guideline	31 Dec. '92	1994	73, 113
V308	NSPS - Comm/Ind. Printing	CCME Code	30 June '93	1994	73, 114
V309	NSPS - Comm/Ind. Degreasing	CCME Code	30 June '94	1995	73, 115
V310	NSPS - Dry Cleaning	CCME Code	31 Dec. '93	1995	74, 116
(b) ILLUSTRATIVE REGIONAL REMEDIAL PROGRAM (See Plan for Regional Application)					
Energy Conservation and Product Control					
V401	Urban Transportation Management	Management Plans	92/94		74, 117

TABLE B NO_x/VOC MANAGEMENT PLAN – PHASE I: VOC REDUCTION INITIATIVES (Cont'd)

Initiative		Control Instrument			Reference Page in Plan
		Type	Delivery Date	Effective Date	
Consumer Choice and Lifestyle					
V501	Ozone Episode Management	Mun. Plans/Criteria	31 Mar. '93	1993	74, 117
Source Control					
V601	Motor Vehicle Inspection and Maintenance (I&M)	Provincial Programs	31 Dec. '93	1994	74, 117
V602	Gasoline Volatility Limit-62 KPa	Provincial Regulation	31 Dec. '91	1992	74, 117
V603	Vapour Bal. - New & Exist. Gas. Depots	CCME Code	31 Dec. '90	1992/1993	75, 118
V604	Vapour Bal. - New & Exist. Serv. Stations	CCME Code	31 Dec. '90	1992/1993	75, 119
V605	Vehicle Refuel - Vapour Balance (Stage II)	CCME Code	31 Dec. '91	1993/1995	75, 120
V606	Retrofit - Volatile Liquid Storage Tanks	CCME Guideline	31 Dec. '91	1994	75, 121
V607	Fugitive Emission Control - Refineries	CCME Code/Prov. Sch.	31 Dec. '91	1993	75, 122
V608	Retrofit - Chemical Plant Processes	Prov. Limits/Schedule	31 Dec. '92	1996	75, 123
V609	Fugitive Emission Control - Chemical Plants	CCME Code/Prov. Sch.	31 Dec. '91	1993	76, 123
V610	Retrofit - Existing Plastics Processing	Prov. Limits/Schedule	30 June '93	1996	76, 124
V611	Retrofit - Existing Pulp & Paper Sulphate Proc.	Prov. Limits/Schedule	31 Dec. '93	1997	76, 125
V612	Retrofit - Surface Coating Facilities	Prov. Limits/Schedule	31 Dec. '92	1996	76, 125
V613	Retrofit - Existing Comm/Ind. Printing	Prov. Limits/Schedule	30 June '93	1996	76, 126
V614	Retrofit - Existing Comm/Ind. Degreasing	Prov. Limits/Schedule	30 June '94	1997	76, 127
V615	Retrofit - Existing Dry Cleaning	Prov. Limits/Schedule	31 Dec. '93	1997	76, 127
V616	Retrofit - Existing Wood Waste Burning	Prov. Limits/Schedule	31 Dec. '92	1995	76, 128

TABLE C NO_x/VOC MANAGEMENT PLAN - PAHSE I: STUDIES AND INVESTIGATIONS FOR PREPARATION OF PHASE II (Cont'd)

Study Initiative		Reference Agencies	Delivery Date	Reference Pages in Plan
Technologies, Control Options and Costs (S300 Series)				
S301	Refine Cost Estimates for VOC Emissions From Major Sources.	Env. Canada	31 Dec. '91	78, 135
S302	Current VOC Emission Controls in Plastics, Pulp and Paper and Wood Transformation.	Env. Canada	31 Dec. '91	78, 135
S303	R&D on Advanced Combustion and NO_x Emission Control Technologies.	Env. Canada EMR	1991-1995	78, 135
S304	Current Control and Product Substitution in All Major Solvent Use Categories	Env. Canada All provinces	31 Dec.'91	78, 136
S305	Control and Product Substitution Options for Major Solvent Use Categories.	Env. Canada All provinces	31 Dec. '91	78, 136
S306	Implications of Greenhouse Gas Control Program for NO_x and VOC Emissions.	Env. Canada EMR, All provinces	Link to GHG Program	78, 137
S307	Analyze Canadian Transportation Network to Determine Potential to Reduce NOx, VOC and CO_2 Emissions by Intermodal Shifts.	Transp. Canada EMR	31 Dec. '91	78, 137
S308	Evaluate Energy Conservation Merits of Labelling and a Retrofit Building Code for Existing Buildings	EMR All province	31 Dec. '92	78, 138
S309	Evaluate the Merits and Develop a Framework for NO_x/VOC Emission Trading	Env. Canada All provinces	31 Dec. '92	78, 138
U.S. Emission Control (S400 Series)				
S401	Analyze New U.S. NO_x Control Program for NO_x Reductions in Selected Regions.	Env. Canada Ont, Que, BC	1991/1993	79, 139
S402	Analyze U.S. State Implementation Plans (SIPs) in Selected Ozone Non-attainment Areas.	Env. Canada Ont, Que, BC	31 Dec. '92	79, 139

TABLE C NO_x/VOC MANAGEMENT PLAN - PAHSE I: STUDIES AND INVESTIGATIONS FOR PREPARATION OF PHASE II (Cont'd)

Study Initiative		Reference Agencies	Delivery Date	Reference Pages in Plan
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S304	Current Control and Product Substitution in All Major Solvent Use Categories	Env. Canada All provinces	31 Dec.'91	78, 136
S305	Control and Product Substitution Options for Major Solvent Use Categories.	Env. Canada All provinces	31 Dec. '91	78, 136
S306	Implications of Greenhouse Gas Control Program for NO_x and VOC Emissions.	Env. Canada EMR, All provinces	Link to GHG Program	78, 137
S307	Analyse Canadian Transportation Network to Determine Potential to Reduce NOx, VOC and CO_2 Emissions by Intermodal Shifts.	Transp. Canada EMR	31 Dec. '91	78, 137
S308	Evaluate Energy Conservation Merits of Labelling and a Retrofit Building Code for Existing Buildings	EMR All province	31 Dec. '92	78, 138
S309	Evaluate the Merits and Develop a Framework for NO_x/VOC Emission Trading	Env. Canada All provinces	31 Dec. '92	78, 138
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Effectiveness of the Phase I Plan

Assuming that regional remedial programs comparable to the illustrative regional program outlined in Tables A and B are implemented, the Phase I Plan, when fully implemented, would achieve the following:

- In the year 2005, national NO_x and VOC emissions that are 11% and 16% respectively below current (1985) emission levels, with emission reductions of about 25 to 40% in the more serious ozone non-attainment areas.

- By 2005, a reduction in summertime peak ozone levels of 15 to 35% in most areas of concern (When combined with NO_x and VOC control measures in the United States).

- A reduction in the number of hours above the "maximum acceptable" ozone concentration (82 ppb) ranging from 40 to 100% in most areas of primary concern. (When combined with NO_x and VOC control measures in the United States.)

- Significant reductions in damage to vegetation as a result of reduced duration of exposure to ozone concentrations above 82 ppb.

- Major reductions (20 to 60%) in some sources of VOCs which are of concern because of their toxicity in addition to their ozone forming potential.

- A reduction in emissions of carbon dioxide (CO_2), of concern because of its contribution to the greenhouse effect, of approximately 6% from the level projected for 2005.

- Conformity with Canada's international obligations under the United Nations Economic Commission for Europe (ECE) NO_x Protocol signed by Canada on October 31, 1988.

    - NO_x emissions under the Plan will be about 5% below the 1987 level by December 31, 1994, the date specified for a freeze at the 1987 level.

    - the Plan calls for national emission standards for major new mobile and major new stationary source categories as specified in the protocol.

- Conformity with Canada's commitment not to increase the transboundary flow of NO_x and VOCs into areas of the United States already experiencing ozone or acid rain problems.

    - the Plan will result in decreases in transboundary flows of NO_x and VOCs to the United States of 25 to 40% in areas of potentially significant transboundary flow (Windsor-Quebec Corridor, Lower B.C. Mainland).

Cost of the Plan

The Plan will result in significant costs to governments and industry, and is dependent to some degree on consumer adaptation and response to the need for lifestyle changes to improve and conserve the quality of the environment.

Two kinds of costs will be incurred. The first, is the cost of conducting investigations and consulting with stakeholders in developing the regulatory instruments and implementation processes necessary to put the Plan in place. If the base prevention, illustrative remedial and study initiatives outlined in Tables A, B and C are implemented, the cost to governments over a 5 year period, 1990-1995, is estimated at approximately $100 million. This is exclusive of industry "participation" costs in the regulatory processes. Some of this cost may be absorbed within existing government air pollution control programs and/or other related initiatives such as federal and provincial programs for the control of greenhouse gases.

The second form of cost will be that of implementing the control measures to reduce NO_x and VOC emissions. These "emission reduction costs", based on implementation of the initiatives identified in Tables A, B and C, are estimated to be $855 million per year by 2005. They are split as follows:

- $415 million per year for NO_x control,
- $440 million per year for VOC control.

Costs will begin to be incurred by NO_x and VOC source sectors in the early 1990s, and increase gradually through to 2005. These costs will be incurred either directly by consumers, or by the various source sectors and subsequently passed on to consumers. It is estimated that 48% of the total cost is associated with motor vehicles, 21% with power generation and 12% with paints and coatings. The remaining 19% is split among numerous NO_x and VOC source categories. Geographically, almost 90% of the control costs will be borne by 3 provinces: British Columbia (11%), Ontario (62%) and Quebec (16%). On a per capita basis, $855 million per year translates into 9 cents per person per day.

The costs of control may be overestimated. The costs of NO_x and VOC reductions due to energy conservation and product substitution measures are estimated to be zero. Most analyzes conclude that energy conservation measures actually result in economic benefits which would offset some of the emission reduction costs. Also, actual emission control costs tend to be less than first estimates, due to technological innovations and other factors.

No estimate has been made of either the administrative costs to governments, or the emission control costs to NO_x and VOC emitters, of implementing alternative control methods, such as emission trading schemes in ozone non-attainment areas.

Recommendations to Ministers

The Federal/Provincial LRTAP Steering Committee made nine specific recommendations to the Canadian Council of Ministers of the Environment. These are that:

1. consistent attainment of the ambient ozone objective of 82 ppb in all areas of the country by the year 2005 be re-affirmed as the overall objective of the Plan.

2. the Phase I Plan, consisting of a national prevention program and interim emission reduction targets for designated ozone non-attainment areas, be endorsed in principle as a major first step towards meeting the 82 ppb objective.

3. there be agreement to seek the necessary resourcing within respective governments to ensure that the Phase I Plan is fully implemented over the 5 year period from 1991 to 1995.

4. there be agreement to seek the necessary cooperation of municipal and regional governments as well as of other government departments such as Energy, Transport, Industry and Health, to implement the Plan.

5. there be agreement on the establishment and maintenance of an implementation tracking system with continuous public access to information on the status of all initiatives and programs undertaken under the Plan.

6. approval be given for establishment of a NO_x/VOC Consultations Office to operate on a one year interim bases and to report to the Environmental Protection Committee (EPC) of CCME. During the one year interim period, the EPC should examine and make recommendations on how implementation of the Phase I Plan should be coordinated over the full 5 year implementation period, and how its coordination should be integrated with the management of other atmospheric issues. The purpose of the office would be to coordinate implementation of the Phase I Plan, inform stakeholders, manage an implementation tracking system, develop public education programs and organize the development of Phase II of the Plan.

7. there be committment to develop Phase II of the Plan in 1994. Phase II will contain those further measures needed to provide consistent attainment of the 82 ppb ozone objective in all areas of Canada by 2005, taking into consideration the effectiveness of U.S. controls, related programs for the control of greenhouse gases, acid rain and toxics in Canada, and other new information.

8. there be agreement to pursue bilateral negotiations with the United States to reduce ozone levels in border states toward the Canadian 82 ppb ozone objective, so that transboundary flows into Canada of ozone or its precursor pollutants do not cause harm to the health or environment of Canadians.

9. bilateral federal provincial agreements be negotiated, within 12 months, defining the interim reduction targets and details of the prevention, remedial and study programs, and the responsibilities and commitments of the various jurisdictions in implementing the Phase I Plan.

Minsiterial Decision

The Canadian Council of Ministers of the Environment endorsed the above recommendations at its Annual Meeting on November 29, 1990.

I. INTRODUCTION

The Canadian Council of Ministers of the Environment (CCME) announced, on October 6, 1988, that a federal/provincial plan would be developed for the further management of emissions of nitrogen oxides (NO_x) and volatile organic compounds (VOCs). The plan was to have two primary objectives:

1) to resolve existing NO_x and VOC related environmental problems in Canada

2) to meet Canadian international obligations relating to NO_x and VOCs.

The task of developing the plan was assigned to the Federal/Provincial Long Range Transport of Air Pollutants (LRTAP) Steering Committee. CCME instructions to the committee were three-fold:

i) the Management Plan should be completed in two years and delivered to CCME by October, 1990;

ii) energy efficiency and energy conservation measures should be an integral part of the Plan; and

iii) the committee should consult with all stakeholders in developing the Management Plan.

This document constitutes Phase I of the Management Plan. Scheduled updates to the Plan recommended for 1994 and 1997 will result in Phases II and III of the Plan in those years.

The Phase I Plan is designed to put in place a solid preventive program nationally, supplemented by regional remedial programs in the major ozone problem areas. The regional remedial programs will be designed to meet interim emission reduction targets which will be established in bilateral federal/provincial agreements for three designated ozone non-attainment areas. These interim targets will be replaced by final NO_x and VOC emission caps in Phase II of the Plan. The final emission caps will be selected to ensure consistent attainment of the Canadian maximum acceptable ambient air ozone standard of 82 ppb in all locations by 2005.

While NO_x and many VOCs are pollutants in their own right, the focus of the Plan is on ground-level ozone (smog), a secondary pollutant formed by a photochemical reaction between NO_x and VOCs in the presence of sunlight. The Plan may help resolve other environmental concerns with NO_x and VOCs, such as direct toxic effects of certain VOCs, but it is not specifically designed for that purpose. Also, some NO_x and VOC control measures could conceivably result in decreases or increases in emissions of other pollutants, such as carbon dioxide and sulphur dioxide. The implications of the Plan for other pollutants and the consistency of the Plan with the objectives of other air pollution control programs, such as those for the control of acid rain and greenhouse gas emissions, were considered in a general way in the preparation of the Plan.

The development of the Plan involved a very comprehensive stakeholder consultation process. This process was used to establish principles and guidance for developing the Plan, to identify information gaps and set the mechanisms in place to resolve them to the degree possible within the established time frame, and to provide an organized framework for stakeholder review of a draft version of the Plan prior to its finalization and submission to CCME.

Preparation of the Plan also involved an extensive review and analysis of information, and in some cases the development of new information, on NO_x, VOCs and ground-level ozone (O_3). This included information on health and environmental effects, the nature of ground-level ozone problems in Canada, emission reductions needed to resolve existing problems, current and future emissions of NO_x and VOCs, and NO_x and VOC management opportunities.

Part of the information was assembled as a result of the stakeholder consultation process, through which a series of Work Groups were established to examine selected topic areas. Reference is made to the Work Group reports throughout the Plan. These will provide essential information for interpreting various aspects of the Plan. They will also be useful in implementing the Plan after it comes into effect, and in some cases identifying NO_x and VOC management opportunities that are beyond the scope of the Plan but could be pursued by industries, organizations or individuals on a voluntary basis.

The Phase I Plan outlines a range of NO_x and VOC reduction measures that represent a starting menu or base set of initiatives for a national prevention program. It also outlines a set of illustrative remedial initiatives that will provide guidance in setting interim emission reduction targets for ozone non-attainment areas and that reponsible jurisdictions may wish to draw upon in developing regional remedial programs to meet the targets. These include emission limits for new and existing facilities, reduction targets for products containing solvents, energy performance standards, and public education initiatives to increase public awareness and stimulate voluntary actions. The Plan contains a schedule for implementation of the measures identified with target dates during the period 1991-2000 for measures to become effective. In addition to the NO_x and VOC management measures identified, a number of actions are proposed to evaluate the Plan and provide the information necessary to produce Phase II of the Plan in 1994.

It is recognized that alternative control packages or schemes may be as effective in reducing ground-level ozone as the base prevention and illustrative remedial measures outlined in the Phase I Plan. The Plan provides the opportunity for jurisdictions responsible for implementation of the prevention program to substitute alternative "environmentally equivalent" control programs. These environmentally equivalent programs may include alternative scheduling of control measures alternative packages of control initiatives, or alternative methodologies for implementation. In regional settings, responsible jurisdictions are expected to develop their own programs, which when combined with emission reductions achieved by the national prevention program, will ensure the interim emission reduction targets for ozone non-attainment areas are met. These programs may be a set of specific reduction initiatives, such as those defined in the illustrative remedial program, or alternative approaches such as regional emission trading schemes.

II. NATURE OF THE PROBLEM

II.1 Summary of Concerns

Some of the environmental and health concerns associated with NO_x and VOC emissions are illustrated in Figure 1.

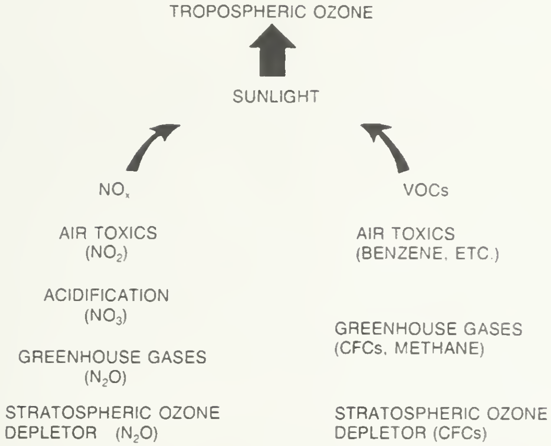

TROPOSPHERIC OZONE
SUNLIGHT
NO_x
VOCs
AIR TOXICS (NO_2)
AIR TOXICS (BENZENE, ETC.)
ACIDIFICATION (NO_3)
GREENHOUSE GASES (CFCs, METHANE)
GREENHOUSE GASES (N_2O)
STRATOSPHERIC OZONE DEPLETOR (N_2O)
STRATOSPHERIC OZONE DEPLETOR (CFCs)

FIGURE 1 NO_x AND VOC RELATED ENVIRONMENTAL AND HEALTH EFFECTS

In addition to their contribution to the formation of the secondary product ozone (O_3), both NO_x and VOCs are pollutants in their own right with potential to cause other adverse environmental and/or health effects than those that are ozone related.

II.2 Sources and Forms of NO_x and VOCs

a) Nitrogen Oxides

Nitrogen oxides (NO_x) can exist in several forms in the atmosphere. Nitrogen oxide emissions from the combustion of fossil fuels, which contributes more than 95% of all NO_x emissions in Canada, are mostly in the form of nitric oxide (NO). Small quantities, usually less than 10%, are in the form of nitrogen dioxide (NO_2), and in the case of stationary fuel combustion, a very small fraction, usually less than 1%, can be emitted in the form of nitrous oxide (N_2O).

Once in the atmosphere, nitric oxide is rapidly converted to NO_2 and other nitrogen species through oxidation and other chemical reactions. These species include particulate nitrate, nitric acid (HNO_3), nitrous acid (HNO2), peroxy acetyl nitrate (PAN) and numerous other inorganic and organic nitrogen compounds. It is also suspected that small amounts of NO may be converted to N_2O in stationary source plumes containing sulphur compounds, although this area is still being investigated.

b) Volatile Organic Compounds

For the purposes of the Plan, volatile organic compounds (VOCs) are defined as compounds containing at least one carbon atom but excluding carbon dioxide and carbon monoxide. Excluded from the definition and from the VOC emission inventories used in the Plan are methane and chlorofluorocarbons. Also effectively excluded are organic compounds with low vapor pressures (<0.1 mm Hg) and/or high boiling points, since these compounds have negligible evaporation rates at typical ambient temperatures and have emission factors of close to zero.

Volatile organic compounds are released during combustion, from various industrial processes, and from the evaporation of liquid fuels, solvents and organic chemicals. A small fraction of the VOC emissions occur as a result of the escape to the atmosphere of gaseous fuels and other gaseous substances during production, storage, handling or end-use.

Not all VOCs are emitted from man made sources. In fact, total emissions of VOCs from natural sources, mainly forests, are estimated to be almost six times greater than the anthropogenic source emissions in Canada (Ortech 1989). In the vast rural areas of Canada, biogenic VOC emissions dominate. However in the more populated and industrialized parts of the country, anthropogenic VOC emission densities can be several orders of magnitude higher than the emission densities of the more widely distributed, natural VOC emissions.

There are many thousands of organic compounds in the natural and polluted troposphere that meet the definition of a VOC. Not all VOCs are equally effective in generating ozone in the atmosphere. Accordingly, VOCs can be classified in terms of their "reactivity", which is defined as the tendency of an organic compound to contribute to the build up of ozone in atmospheres containing NO_x. For most VOCs, reaction with hydroxyl radicals is the only significant route towards ozone formation. One of the most common methods for measuring VOC reactivity is thus the use of hydroxyl radical rate coefficients. The more reactive VOCs (those having high rate coefficients) are rapidly degraded in the atmosphere by hydroxyl radicals; this results in the formation of other free radical species that can participate in the reactions leading to ozone formation. Table 1 lists major VOC classes and species, hydroxyl radical rate coefficients and relative reactivity by weight (rate coefficient divided by molecular weight). The hydroxyl radical rate coefficient is only one measure of reactivity and this method of defining reactivity ignores processes that ultimately determine how much ozone is formed from the reaction of individual VOCs. Other approaches are under development (ARB 1990, Derwent 1990) that will allow a better ranking of the overall ozone forming potential of individual VOCs. This information will be used in future refinements of the Plan.

Regardless of the classification scheme used, the issue of reactivity is most relevant to peak ozone formation in urban or near-urban areas. Very few VOCs are of such low reactivity that they can be ignored in ozone control programs.

Because of the lack of an adequate measure of the ozone forming potential of VOCs for all time scales of interest, the Plan currently treats all VOCs as of equal importance and makes no attempt to differentiate control options based on the reactivity of the VOCs controlled. It is recognized,

TABLE 1: HYDROXYL RADICAL RATE COEFFICIENTS (k) FOR SELECTED VOCs (DANN, 1989)

Category	Name	Molecular Weight	k X 10-3 (ppm-1 min-1)	Relative Reactivity by Weight
Alcohol	Methanol	32	1.4	43
	Ethanol	46	4.8	105
Alkane	Methane	16	0.012	1
	Ethane	30	0.396	13
	Propane	44	1.7	39
	n-Butane	58	3.8	65
	n-Hexane	86	8.3	96
Alkene	Ethylene	28	12.6	448
	Propene	42	38.8	925
	1-Pentene	70	46.4	662
	cis-2-Butene	56	83	1488
	1,3-Butadiene	54	98	1822
Alkene (Biogenic)	Isoprene	68	149	2191
Alkyne	Acetylene	26	1.2	46
Aromatic	Benzene	78	1.8	23
	Toluene	92	8.8	96
	m-Xylene	106	34.9	328
	1,3,5-Trimethylbenzene	117	84.9	726
Carbonyl	Formaldehyde	30	14.4	481
	Acetone	58	0.33	6
	Methyl ethyl ketone	72	1.7	24
Carboxylic Acid	Formic acid	46	0.7	14
Cl. Alkane/Alkene	Dichloromethane	85	0.22	3
	1,1,1- Trichloroethane	134	0.03	0
	Tetrachloroethylene	166	0.25	2
Cl. Aromatic	Chlorobenzene	113	0.59	5
Ether	Dimethyl ether	46	4.4	95
	Methyl t-butyl ether	88	4.2	47

however, that there is a wide variation in the VOC species profile of individual sources, with some source sectors ultimately generating more ozone per tonne of VOC emitted. Future modelling efforts will help to better refine VOC control options based on reactivity considerations; and these will be used in subsequent editions of the Plan.

Many of the compounds important in ozone formation derive from anthropogenic sources. However, natural VOC emissions can also play an important role. Of the total natural VOC emissions for Canada, it is estimated that 12% are isoprene and 50% are mono-terpenes. Terpenes are not included in many atmospheric chemistry schemes because it is believed that the oxidation products of these compounds do not play an important role in ozone formation (Sillman 1987, Finlayson-Pitts 1987, Altshuller 1983). Isoprene, however, can be an important contributor to rural ozone formation.

Long-lived low reactivity VOCs such as chlorinated alkanes and chlorofluorocarbons make no significant contribution to peak ozone concentrations. They often remain largely unreacted for many years, giving them adequate time to reach the upper atmosphere. Chlorofluorocarbons (CFCs) are primary contributors to stratospheric ozone level depletion and are also greenhouse gases. Methane is another long-lived VOC which contributes to the greenhouse effect. Even though it has very low reactivity, methane is also a major contributor, along with NO_x, to the observed long term buildup of background tropospheric ozone in the Northern Hemisphere (Sillman 1987, Altshuller 1986, FRG 1989, Zierock 1988). As noted previously, both methane and chlorofluorocarbons are excluded from the definition of a VOC used to determine total Canadian emissions.

Many individual VOCs are known or suspected of having direct toxic effects on humans, ranging from carcinogenesis to neurotoxicity (Dann 1989, Shane 1989). These are described in more detail in Section II.4 (b).

II.3 Tropospheric Ozone Concerns

a) Health Effects

Elevated ozone levels have been shown to cause adverse effects on human health (Bates 1989, McKee 1988, Friedman 1988, U.S. EPA 1988, Lippmann 1989). Human health effects include immediate, short term changes in lung function and increased respiratory symptoms such as cough and pain on deep breathing. Studies of healthy individuals in controlled chambers show that exposure to ozone results in a decrement in lung function and causes respiratory symptoms at concentrations as low as 0.12 ppm if moderate to heavy exercise is taken for a period of several hours (EPA 1988). Prolonged exposures (for up to 6.5h) to ozone concentrations in the range of 0.08 to 0.12 ppm show progressively larger lung function decrements as duration of exposure at moderate exercise levels increases (EPA 1988). Studies in which exercising adults and children were observed in the natural summer atmosphere (containing ozone, sulphates and H_2SO_4) indicate that induced decrements are slightly larger than those obtained in chamber experiments where only ozone was present (Bates 1990). Even though lung function decrements are transient (ie. the effect disappears following the termination of ozone exposure) it is the opinion of most health professionals that these decrements do represent an adverse health effect (Bates 1990). Epidemiological studies have established correlations of ambient air ozone concentrations with hospital admissions for acute respiratory diseases (Bates 1987, Bates 1989).

Ozone is strongly suspected of playing a role in the long term development of chronic lung diseases. While not dismissing the short term effects of ozone, many health professionals appear to be more concerned that repeated exposure to ozone over a lifetime may result in permanent impairment of the lung. New epidemiologic research suggests that accelerated rates of decline of lung function with aging occur among residents of communities with high ozone concentrations. Clinical studies of humans have recently shown that prolonged exposure to low ozone concentrations results in progressively larger changes in respiratory function and symptoms with time. Animal studies have shown that prolonged ozone exposure can cause biochemical and structural injury to the lung. Some of these changes are suspected of playing a role in the development of chronic lung disease, although inherent uncertainties in extrapolating from animal data make it difficult to assess human risk from these studies. Current consensus in the U.S. is that chronic exposure to existing ozone concentrations is an important health issue and will be carefully considered during the review of the current primary ozone standard (McKee 1990).

Many factors may affect susceptibility to ozone exposure, including age, sex, smoking status, nutritional status, environmental stresses, and exercise level during exposure. At present, scientists postulate that about 5 to 20% of the healthy population may represent a subgroup of "responders" (EPA 1988) who may be significantly more responsive than the general population to the same dose of ozone. Also considered "at risk" are asthmatics, people with pre-existing lung disease, children, the elderly, and individuals who exercise heavily or work outdoors. Within each of these groups, some individuals have demonstrated greater than average sensitivity to a specified dose of ozone, although no particular group has proven to be more sensitive than the others. (Friedman 1988)

The strongest evidence for increased responsiveness exists for groups who exercise intensively outdoors because the dose of ozone they receive is much higher than average due to their increased breathing rate. Because individuals with pre-existing lung disease already have compromised respiratory systems, there is concern that lung function changes and other respiratory effects may be more serious for these people than for the normal, healthy population. (Friedman 1988)

Results of studies on asthmatics are mixed. A number of epidemiological studies of asthmatics have suggested that ozone exposure may be associated with increased asthma attacks, hospital admissions for asthma, decrements in lung function, and symptoms. Asthmatics have also participated in studies in which lung function and symptoms were assessed before and after breathing ozone in a controlled laboratory environment. These studies have consistently shown that the lung function and symptom responses of asthmatics to a specific level of ozone do not differ from the responses of healthy non-asthmatics. The discrepancy between results in epidemiologic and chamber studies may also be due to interaction between ozone and other environmental factors (e.g., other pollutants, high temperatures and humidity) in the field. In other words, there may be factors operating in the ambient environment that have not been replicated in clinical studies (Bates 1990).

One of the reasons why there is concern about ozone effect on asthma is that there is evidence that hospital admissions for asthma are increasing in many areas (Bates 1990); although not all of these are in areas affected by increasing levels of air pollutants.

Patients with chronic obstructive pulmonary disease (chronic bronchitis, emphysema), many of whom are former smokers, are also of concern as an "at risk" subgroup because they already have poor lung function and, compared to healthy individuals, relatively small decrements in lung function could be adverse for them.

Children are another potentially susceptible subgroup of concern. Since the lungs continue to develop until adulthood, the critical question regarding children exposed to ozone is whether repeated exposure will influence lung maturation. Relatively low concentrations of ozone (at or around the standard) do appear to have an adverse impact on the lung function of active children. On the basis of both controlled exposure studies and field studies of ambient pollutant exposure, however, children do not appear to have lung function effects that are much different than those experienced by adults (Friedman 1988).

b) Vegetation Effects

The effects of ozone on vegetation have been well documented. Vegetation damage is usually in the form of foliar injury which reduces productivity. It is estimated that at many locations throughout the southern and eastern halves of the United States, rural ozone concentrations are high enough to reduce yields of economically important crops by 1 to 20% compared to yields that would be expected if ozone concentrations were at natural background levels. The most heavily affected crops include soybeans, wheat, cotton and some types of produce. Agricultural benefits of about $2 billion would be anticipated in the U.S. if rural ozone concentrations could be reduced by 25%.

Most Canadian research has focused on ozone injury to crops in southern Ontario, where the highest growing season ozone levels occur. Ozone sensitive crops in this area include beans, tomatoes, tobacco, potatoes, corn, soyabeans and wheat. It is estimated that the combined losses in crop production and revenues to ornamental plant growers in southern Ontario from ozone is $17 to $70 million per year, depending on the frequency of ozone episodes (Pearson and Donnan 1989).

Ozone causes foliar injury and reduced growth rates in sensitive trees of several species. Exposure to ozone can lead to increased susceptibility to diseases and other stresses, increased mortality of individual trees, and eventually to overall decline of affected species. All of these effects of exposure to ozone have been observed in forests in the mountains bordering the Los Angeles basin. Ozone damage has also been observed in ponderosa and Jeffrey pine at other locations in California. With regards to forests in eastern North America, both the extent of forest decline and causal mechanism remain controversial (Taylor 1987), although ozone has been suggested as a causal or contributing agent in reported decline of red spruce, yellow pine and sugar maple (Friedman et al 1988). Given the general air quality in eastern North America, which includes a mix of wet and dry deposited pollutants, it is suggested that air pollution stress has become an important factor influencing the growth of sensitive tree species (Taylor 1987).

Although many forest species in Ontario, Quebec and the Maritime provinces have been shown to be in a state of decline, the state of knowledge at this time is insufficient to develop reliable estimates of the contribution of air pollutants, including ozone, to this decline.

For assessing the possible impacts of ozone on agricultural crops and forests, researchers have focused on characterizing ozone exposure in biologically meaningful ways (Lefohn 1989). Recent studies have shown that the use of long term averages such as a 7 hour seasonal mean may not provide an accurate description of significant exposures that actually occur. Recent studies support the use of a criteria based on cumulative exposure to ozone above a certain concentration threshold during the growing season, or alternatively to one based on weighting individual hourly concentrations and summing all values over time. Higher ozone concentrations are assigned a higher weighting factor in this scheme. At this time, there is no clear preference for an ozone objective that would protect sensitive vegetation (Lefohn 1989); total hours with ozone concentration greater than 82 ppb may be as useful a criteria as any to assess potential vegetation impacts.

c) Ozone Levels and Trends

There are two types of concern with regard to elevated ground-level ozone concentrations:

1) the general increase in "background" levels both in Canada and in the rest of the northern hemisphere; and

2) short duration ozone episodes (hours to days) during which acceptable health and environmental concentrations are exceeded.

Background O_3 is associated with stratospheric O_3 intrusion into the troposhere, with photochemical formation processes involving natural VOCs (including methane) and NO_x emissions, and with anthropogenic NO_x, VOCs (including methane) and CO emissions. Using observations of ground level ozone made in the 1890's (versus observations made in the 1970-1985 period), estimates of stratospheric/tropospheric ozone mass exchange rates, and the results of tropospheric photochemical models, it has been estimated that the natural background of ozone during the summer near ground level is in the range of 10 to 20 ppb (Altshuller 1987). This can be compared to monthly mean ozone concentrations of 35 to 55 ppb measured during May to August at many eastern North American sites and means of 30-40 ppb measured at "clean" western sites (Angle and Sandhu 1989, Lefohn 1989). Thus, at the present, depending on location, natural background ozone accounts for only one-fifth to one-half of observed rural ozone concentrations.

Tropospheric models suggest that the increase in ozone concentration in the free troposphere over "natural background" is largely related to an increase in anthropogenic NO_x emissions; the models agree well with observations in terms of both trends and absolute levels. In the summertime, very high ozone concentrations can be generated in polluted air masses on both urban and regional scales. These peaks are superimposed on the elevated background, increasing both the magnitude of peak concentrations during O_3 episodes and the number of hours per year that O_3 levels exceed the maximum acceptable concentrations as defined by Canadian air quality objectives (Appendix B).

In Canada, ozone episodes occur almost exclusively during summer months and primarily on hot sunny days. In eastern Canada, meteorological conditions associated with stable high pressure systems located over the eastern U.S. seaboard lead to the highest ozone concentrations. Transport of ozone and precursors from the United States can be an important feature in some episodes. Ozone episodes are generally of relatively short duration (1-5 days). Peak O_3 concentrations during typical episodes in parts of Canada are often more than twice the maximum acceptable level of 82 ppb. The location of ozone problem areas and the average number of days with ozone concentrations above 82 ppb (1982-86) are illustrated in Figure 2. Because the highest levels normally occur in the more highly populated regions of the country, it is estimated that during the summer months more than half of the Canadian population is exposed to O_3 levels which are known to have adverse health effects.

Over the past seven years (1983-1989), Saskatoon and Victoria are the only major urban areas (populations greater than 50,000 where routine monitoring takes place) in Canada that have not recorded ozone concentrations in excess of the maximum acceptable level. The urban areas in the B.C. Lower Mainland and the Windsor-Quebec City corridor, Saint John, New Brunswick and Western Nova Scotia are the areas where ozone levels most frequently exceed environmental quality requirements.

Appendix D contains a listing of maximum ozone concentrations and hours per year above the Canadian maximum acceptable concentration of 82 ppb for most monitoring sites in the country, for the period 1983-1989. In Figures 3 and 4, boxplots are used to show the range of ozone maxima and hours greater than 82 ppb for monitoring sites in four regions. The plotting convention for the boxplots is shown in each figure; the percentiles refer to the percentage of sites having ozone maxima or hours >82 ppb equal to or less than the plotted values. The average of the three highest yearly ozone maxima for each site during the period 1983-1989 was used to generate the plot in Figure 3. As shown in Appendix D and as discussed in Chapter V there is substantial year to year variation in the frequency and severity of ozone episodes. This variability is primarily a function of meteorology and, most importantly, temperature. Summers that have a higher frequency of high temperature days than normal will be more conducive to high ozone concentration occurrence. The three high year average represents "typical" ozone maxima during ozone conducive summers. Figure 4 gives the distribution of number of hours >82 ppb by region, again using the average of the three highest years between 1983-1989.

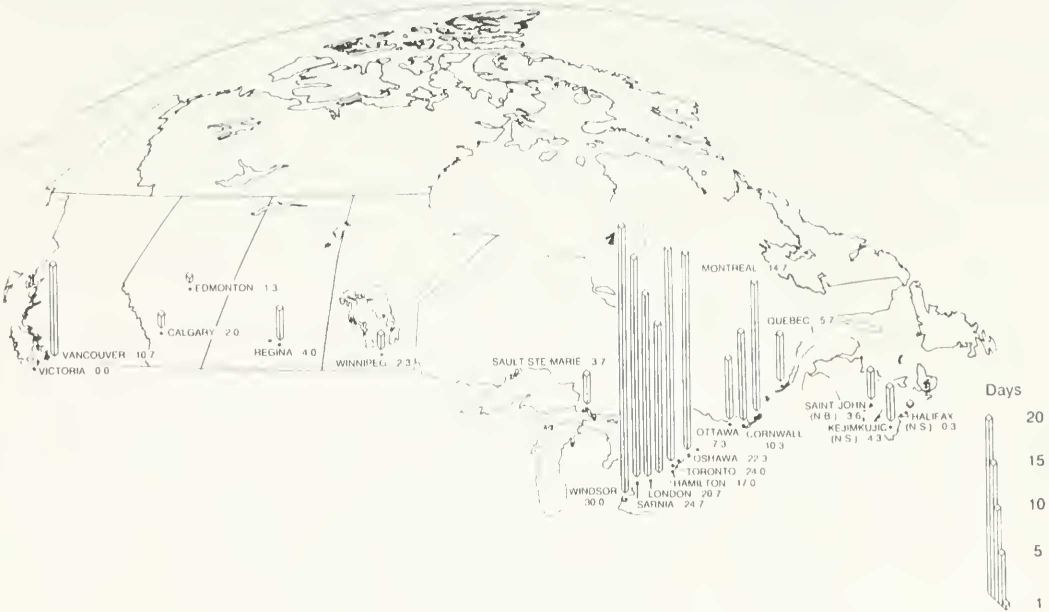


FIGURE 2. DAYS PER YEAR EXCEEDING THE 1-HOUR OZONE AIR QUALITY OBJECTIVE (82 ppb)
— AVERAGE OF 3 HIGHEST YEARS 1983–1989

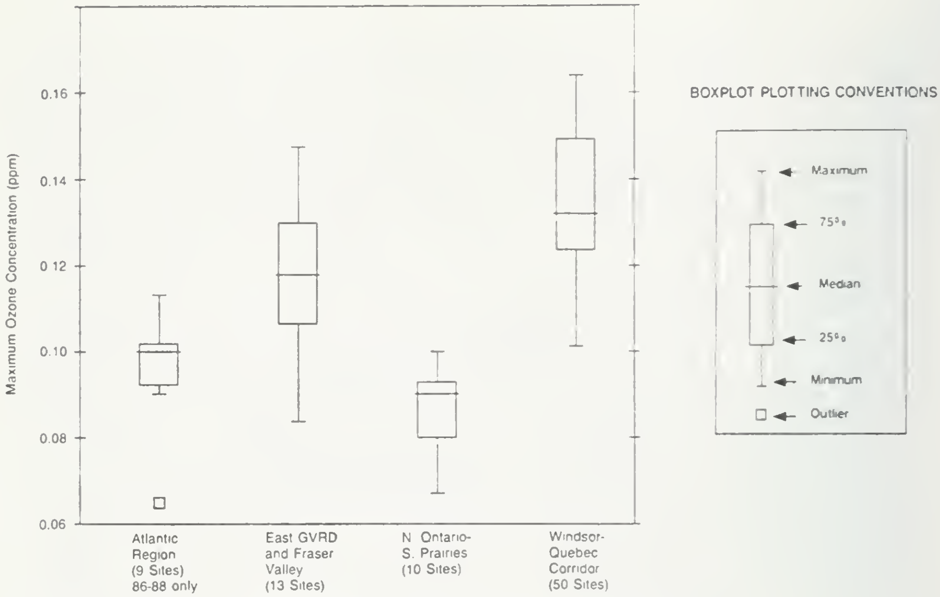


FIGURE 3 AVERAGE MAX. OZONE FOR THREE HIGHEST YEARS 83-89

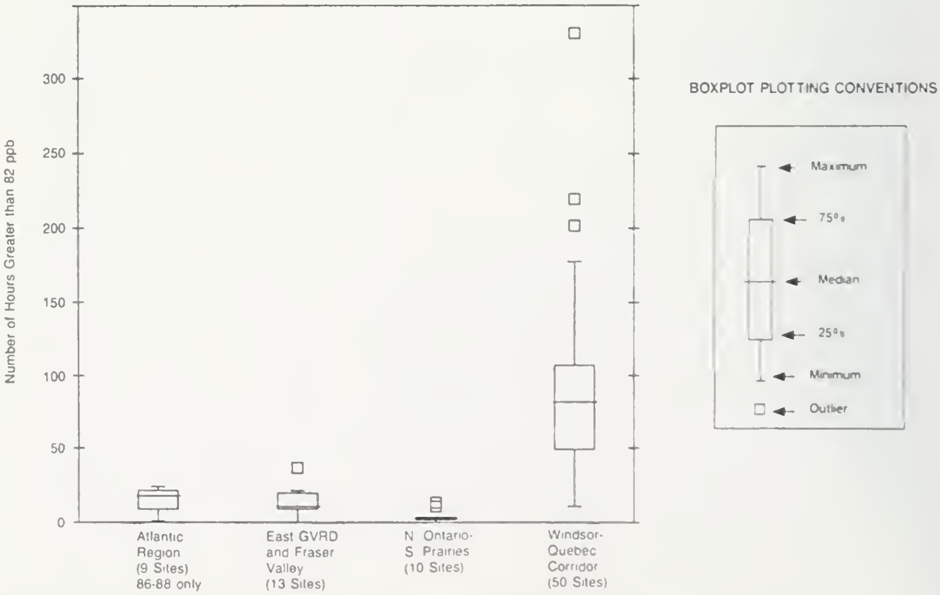


FIGURE 4 AVERAGE HRS >82 ppb FOR THREE HIGHEST YEARS 83-89

The plots in Figures 3 and 4 indicate that, except for the northern Ontario - southern Prairies region, all sites exceeded the 82 ppb maximum acceptable level. Even in the Prairie region more than 50% of sites had average ozone maxima >82 ppb. Hours per year with ozone concentrations above 82 ppb are much higher in the Windsor-Quebec corridor than in any other region. Although ozone maxima for the Greater Vancouver Regional District - Lower Fraser Valley sites were much higher than for the Atlantic sites, the number of hours >82 ppb were very similar for both regions.

d) Regional Air Quality

Because the severity and frequency of ozone episodes vary in different parts of the country it is useful to examine several regional settings in more detail. The ozone situation in each of four geographic regions is described below.

Lower Fraser Valley

The Lower Fraser Valley (LFV) region is considered to encompass the Greater Vancouver Regional District (GVRD) and the areas to the east as far as Chilliwack (it should be noted that part of the State of Washington lies within the Fraser Valley airshed).

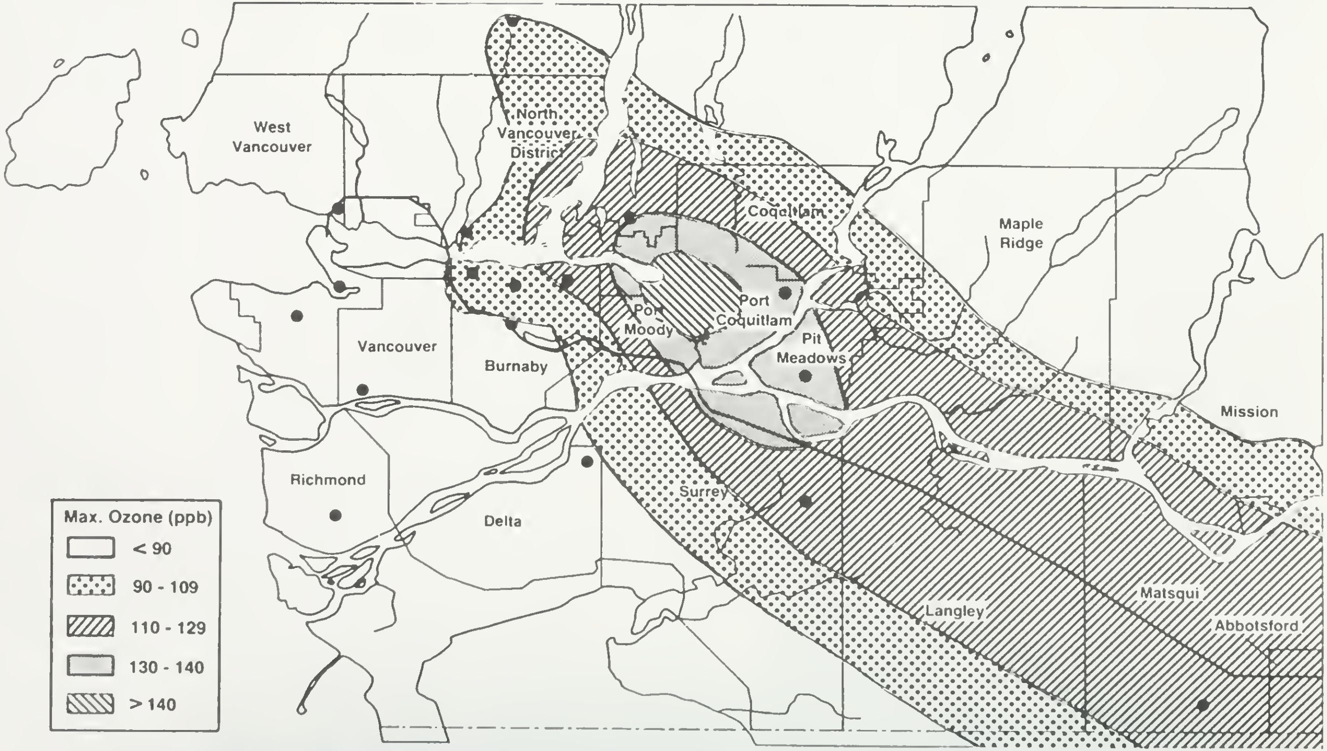
This is a unique geographic setting where mountains immediately inland cause air masses moving inland off the Strait of Georgia to rise and be channeled between mountain ranges. As illustrated in Figure 5, sites near the eastern end of the Burrard inlet experience the highest concentrations of ozone with average peaks in the 150 ppb range. Concentrations greater than 200 ppb have been measured at times. When episodes occur, levels in the 110-130 ppb range can occur 50-100 km downwind into the Fraser Valley, well beyond the primary NO_x and VOC source area. Within the GVRD itself, the meteorology is quite complicated with onshore-offshore movement and micro-scale influences on ozone concentrations (Davis 1984, Concord 1989).

Peak ozone concentrations in the Port Moody-Port Coquitlam area of the LFV are caused primarily by NOx and VOC emissions from the GVRD. Further up the Fraser Valley elevated ozone concentrations are influenced by transported NO_x and VOCs from the GVRD and at times by the transport of ozone and precursors from the Puget Sound area of the State of Washington.

Northern Ontario and Southern Prairies

This region encompasses the portion of Ontario north and west of Sault Ste. Marie, and the southern part of the three prairie provinces. Based on available data, ground-level ozone throughout this region does not appear to be a serious problem.

In this region, Alberta is the province with the highest emissions of NO_x and VOCs. Based on monitoring data from Edmonton and Calgary, there were few ozone concentrations greater than 82 ppb recorded between 1983-1989. Monitoring at rural sites in Alberta carried out in 1978-1979 showed that mean ozone concentrations were similar to those for other "clean" sites in the western United States (Angle and Sandhu 1985, Lefohn 1989). At a site in the foothills of the Rockies (Fortress Mountain), where monitoring was carried out in 1987, a maximum ozone concentration of 122 ppb was measured. At this site there were more than 70 hours with ozone concentrations greater



Maximum Ozone Concentrations (ppb)
(Average of 3 Highest Years 1983 - 1989)

FIGURE 5 MAXIMUM CONCENTRATIONS IN THE LOWER FRASER VALLEY (LFV) REGION

than 82 ppb. These peak ozone values were suggested to be due to long range transport from British Columbia and the state of Washington (Legge 1988), however, additional monitoring would be required to support this conclusion. There is currently no ozone monitoring carried out in rural areas of Alberta.

Alberta has relatively high total NO_x emissions but the sources are quite widely dispersed, with a lower percentage of emissions occurring in large urban areas than in any other province. Figure 6 shows predicted (based on the Climatological Dispersion Model) NO_x concentrations in Alberta based on 1987 emissions data (Legge 1988). Most of the province would have NO_x concentra- tions <5ug/m^3. This can be compared to southern Ontario - southern Quebec where NO_x concentrations are expected to be in the range of 16 to 32 ug/m^3 (Fay 1987).

Ozone maxima greater than 82 ppb occur occasionally in Regina and Winnipeg; there were no hours >82 ppb in Saskatoon between 1983-1989. No monitoring for ozone outside of these cities has been carried out in Manitoba or Saskatchewan. Total NO_x and VOC emissions in these two provinces are much lower than in Alberta. However, unlike Alberta, a very high proportion of total provincial NO_x and VOC emissions are concentrated in the urban centres.

In all three prairie provinces the influence of imported pollutants from U.S. sources on urban ozone episodes is expected to be minimal.

Sault Ste-Marie is on the boundary of the high ozone area in the southern portion of the province of Ontario and experiences more frequent hours >82ppb than the prairie cities, but with similar maxima (~100 ppb). In the period 1983-1989, Thunder Bay recorded ozone concentrations greater than 82 ppb in only one year (1985), when the maximum ozone value reached 90 ppb. Emission densities of NOx and VOCs are very low in northern Ontario, and transport of ozone and precursors from the U.S. does not appear to be a major problem.

Windsor - Quebec Corridor

For the purposes of this Plan, the Windsor-Quebec Corridor (WQC) is considered to be a relatively narrow band along the north shores of Lake Erie, Lake Ontario and the St. Lawrence River in Ontario, and continuing along the St. Lawrence River from the Ontario border to Quebec City in Quebec.

It is within the WQC that the highest frequency and longest duration of ozone excursions above the maximum acceptable level occur. The distribution of maximum hourly ozone concentrations (based on the average of the three highest years between 1983-1989) in southern Ontario and southern Quebec is shown in Figure 7. In the region from Windsor to immediately downwind of Toronto, peak ozone levels are typically in the 110-160 ppb range, with maximum recorded values of about 190 ppb. As one proceeds northeasterly from Toronto along the corridor there is a slight dip in ozone peak levels between Toronto and Montreal, with summer peaks typically in the 90-130 ppb range. These increase again in and immediately downwind of Montreal to levels typically in the 100-160 ppb range, with a maximum recorded hourly value of 180 ppb. From Montreal toward Quebec City, peak levels tend to decrease gradually (based on limited data from rural sites for 1987 and 1988). Although hourly values as high as 160 ppb have been recorded in Quebec City, peak O_3 levels are typically in the 70-110 ppb range.

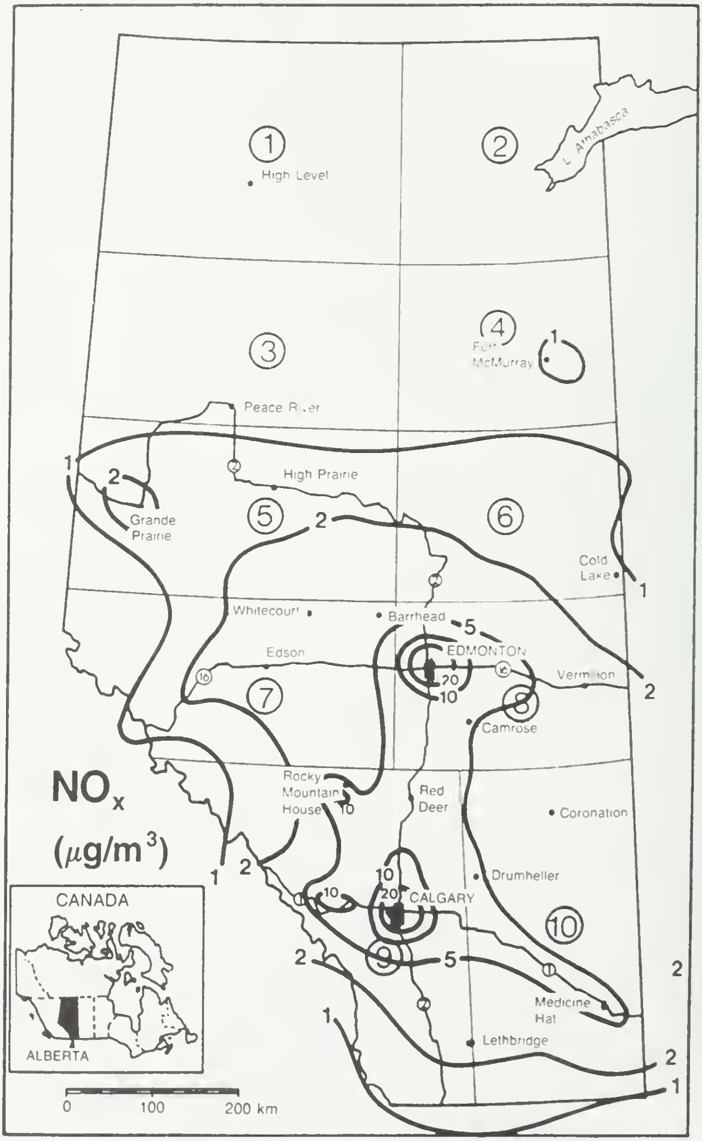


FIGURE 6 AVERAGE ANNUAL NO_x CONCENTRATIONS ($\mu g/m^3$) IN ALBERTA (LEGGE 1988)

(Average of 3 Highest Years 1983 - 1989)

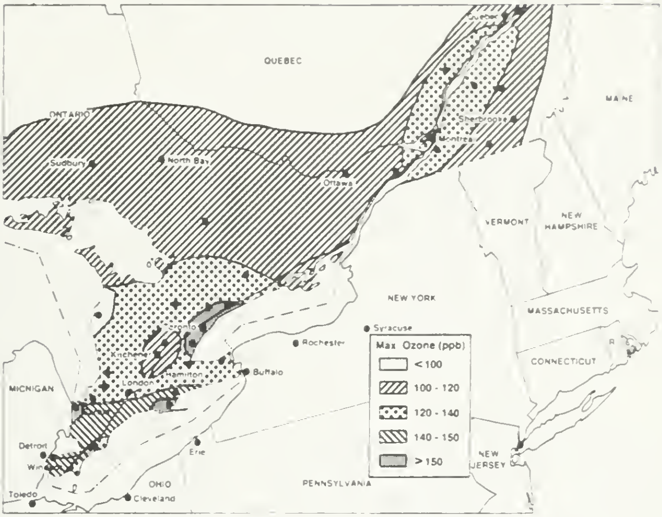


FIGURE 7 MAXIMUM OZONE CONCENTRATIONS — WINDSOR-QUEBEC CORRIDOR (WQC)

(Average of 3 Highest Years 1983 - 1989)

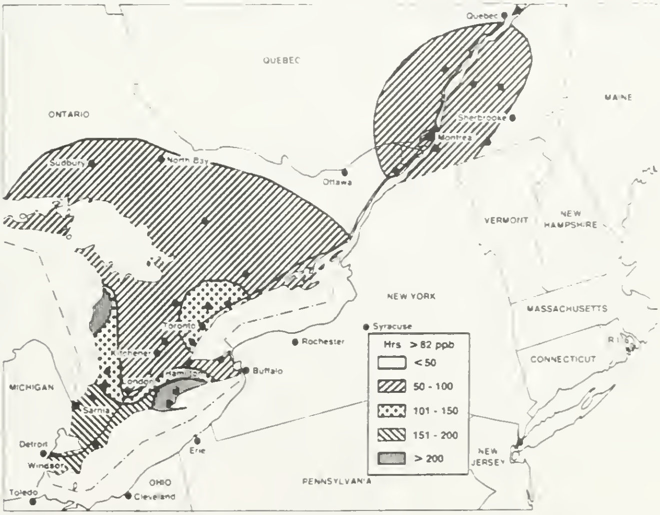


FIGURE 8 NUMBER OF HOURS WITH OZONE > 82 ppb — WINDSOR-QUEBEC CORRIDOR (WQC)

Figure 8 shows the distribution of hours >82 ppb by site, again using the average of the three highest years 1983-1989. The distribution of hours >82 ppb is different from that for maximum ozone. The southwestern corner of Ontario and the sites immediately north of Lake Erie (Long Point and Simcoe) and east of Lake Huron (Kincardine area) have experienced the greatest number of hours >82 ppb (average of greater than 150 hours). The Montreal area and downwind sites generally record far fewer hours of ozone greater than 82 ppb than do the southern Ontario sites (see Appendix D). As discussed in Section II.3(b) total hours >82 ppb is one of the proposed exposure indices for assessing potential impact of ozone on vegetation. The areas with greatest number of hours >82 ppb, as shown in Figure 8, would thus be expected to be the areas with greatest potential for crop and other vegetation damage.

While there are very significant sources of NO_x and VOCs within the WQC, imported O_3, NO_x and VOCs from the United States are expected to have a major influence on both peak O_3 levels and on total hours greater than 82 ppb.

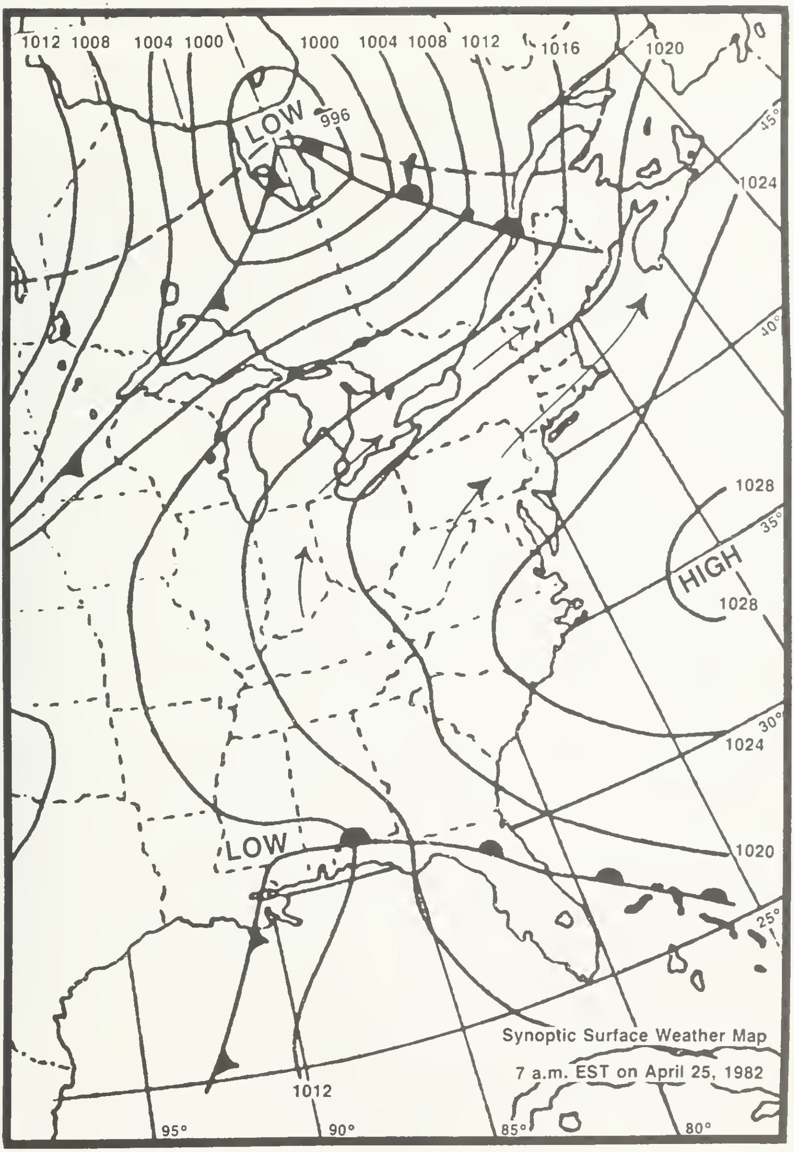
Ozone episodes in the WQC generally occur under prevailing south westerly winds along the backside of anti-cyclones (high-pressure areas) as illustrated in Figure 9. Northeasterly flowing air masses pick up pollutants from major U.S. sources along the southern shores of the Great Lakes and farther upwind and carry them down the corridor. The metropolitan areas of Detroit (population 4.5 million)and Cleveland (population 2 million), both large sources of NO_x and VOCs, sit essentially at the head of the corridor. Under southwesterly winds, high ozone concentrations in the southwestern parts of the corridor will be due almost entirely to imported pollution. The fact that the Long Point area has the greatest number of hours above the maximum acceptable O_3 level supports this conclusion. As one moves down the corridor to Toronto and beyond the influence of U.S. sources diminishes gradually as the distance downwind from these sources increases and major Canadian emission sources are encountered. (See further analysis in Section V)

Southern Atlantic Region

The Southern Atlantic Region (SAR) covers the land areas around the Bay of Fundy including southern New Brunswick and all of Nova Scotia west of Halifax.

Based on 1986-1988 monitoring data, peak ozone concentrations in the 90-110 ppb range occur in the Pt. Lepreau area of New Brunswick, in Saint John, in central Nova Scotia, and on the south shore of the Bay of Fundy (Figure 10). The highest peak ozone concentration (150 ppb) measured in the area was recorded at Kejimkujik National Park in west central Nova Scotia. Ozone levels in Halifax-Dartmouth are usually below 82 ppb but levels of 90-110 ppb were recorded at a site 40 km north of the Halifax metropolitan area. Total hours >82 ppb were in the range of 10 to 20 at most sites (see Appendix D).

Ozone episodes in the SAR can be attributed largely to imported pollutants from the eastern seaboard of the United States. This is supported by the fact that peak ozone levels often occur in the middle of the night, while locally generated ozone peaks would be expected to occur in late afternoon. Weather patterns during episodes in the SAR are similar to those during episodes in the WQC.



Synoptic Surface Weather Map

7 a.m. EST on April 25, 1982

FIGURE 9 TYPICAL WEATHER PATTERN DURING OZONE EPISODES IN THE WINDSOR-QUEBEC CORRIDOR (WQC)

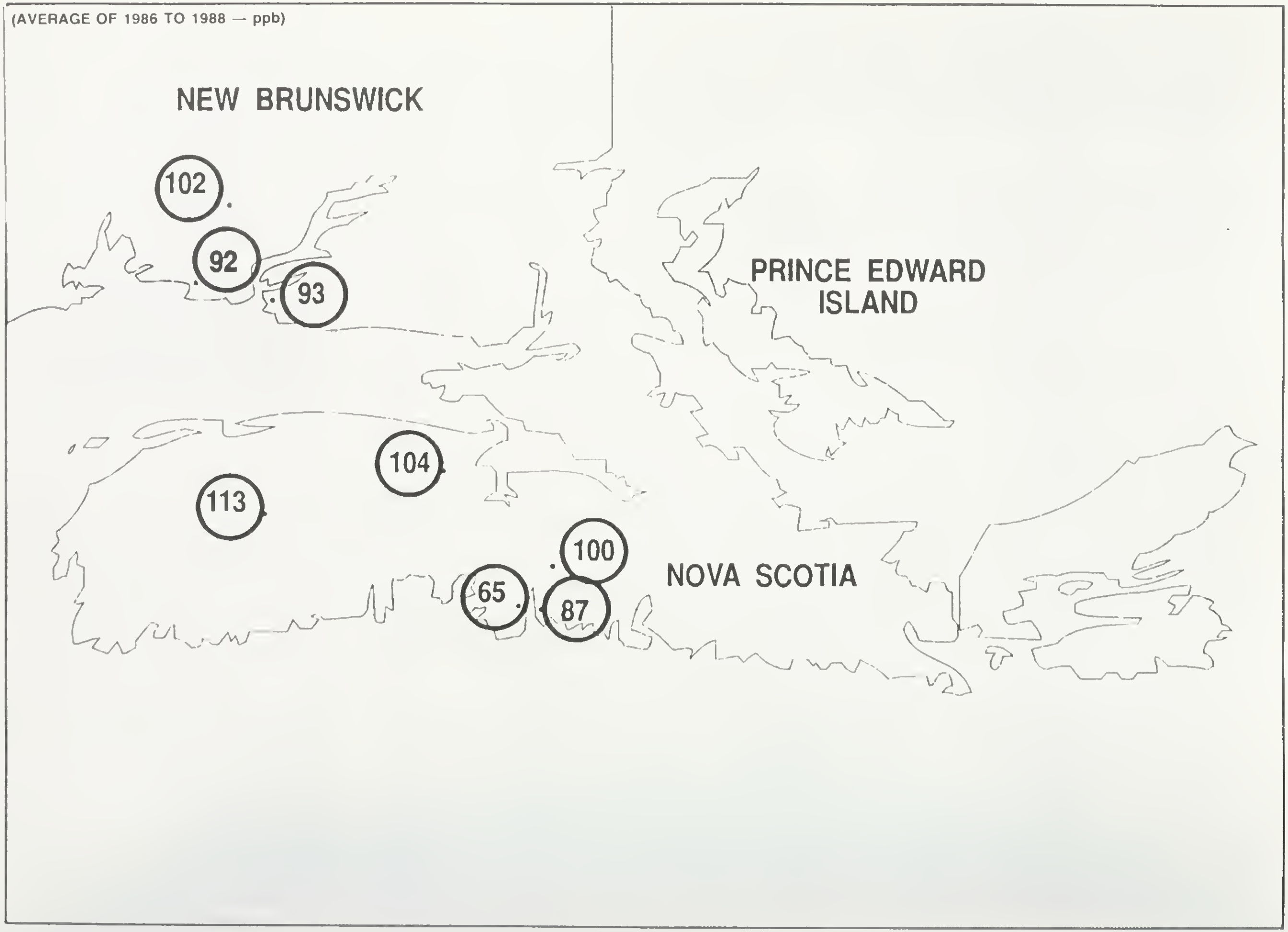

(AVERAGE OF 1986 TO 1988 — ppb)

FIGURE 10 MAXIMUM OZONE CONCENTRATIONS — ATLANTIC PROVINCES

II.4 Other Environmental Concerns with NO_x and VOC Emissions

a) Nitrogen Compounds

Nitrogen Dioxide

Above certain concentrations in the atmosphere, nitrogen dioxide (NO_2) can cause human health effects such as respiratory problems. Canadian ambient air quality objectives are in place defining the maximum desirable, maximum acceptable and maximum tolerable levels of NO_2 in the atmosphere (see Appendix B). Nitrogen dioxide ambient air concentrations have generally been decreasing in recent years, due to declining NO_x emissions from automobiles, and are now generally below the maximum acceptable level in Canadian cities. Although there were some exceedances in 1987 and earlier years, no sites in the country exceeded the maximum acceptable air quality objectives for NO_2 in 1988. Annual average NO_2 levels in urban centres in 1988 were typically in the range of 15 to 35 ppb (the maximum acceptable level is 53 ppb).

Nitrate and Nitric Acid

The long term acidification of surface waters in Eastern Canada is primarily associated with emissions of sulphur dioxide (SO_2). However, nitrate deposition may be aggravating acidification in some areas. No critical load has been established yet for nitrate deposition in Canada. Based on international work in this area, a value somewhere in the range of 5-15 kg/ha/yr (as total nitrogen) may be selected eventually. Maximum total wet nitrogen deposition in Canada is currently about 10 kg/ha/yr. Assuming that dry nitrogen deposition contributes 30-60% of total nitrogen deposition (CCME 1989), total nitrogen deposition in some areas could already be in the 15-25 kg/ha/yr range, or above the upper boundary of the range being considered for a nitrate critical load.

Nitrogen compounds are known to be a significant contributor to spring "acid shock" in some areas of eastern Canada. Also, any contribution of nitric acid to increased acidity of the precipitation itself will accentuate direct effects, such as structural damage to buildings.

It has been suggested that beneficial effects of nitrogen deposition due to an increased nutrient supply to vegetation can be expected with moderate rates of nitrate deposition. However, in parts of Canada where nitrate deposition is highest, NO_x control actions to decrease total nitrate deposition appear to be justified.

Nitrous Oxide

Approximately one third of total global nitrous oxide (N_2O) emissions are anthropogenic, resulting mainly from fertilizer application and to a lesser extent from large stationary combustion sources. Mobile sources are not significant emitters of N_2O.

N_2O is a small contributor (5%) to global atmospheric warming, and also has the potential to contribute to stratospheric ozone depletion. However, in the circumstances which prevail at present, with elevated levels of chlorine compounds in the stratosphere (mainly due to chlorofluorocarbons), ozone depletion is slowed by increasing N_2O concentrations due to interference of the N_2O with the chlorine-catalyzed destruction of ozone. This situation is likely to prevail for decades.

b) Volatile Organic Compounds

Direct Toxic Effects

Many individual VOCs are known or suspected of having direct toxic effects on humans, ranging from carcinogenesis to neurotoxicity (Dann 1989, Shane 1989). About half of the 44 substances on the current Priority Substances List (PSL) of the Canadian Environmental Protection Act are VOCs, ranging from benzene, a component of gasoline, to high volume industrial solvents such as dichloromethane (see Table 2). All substances on the PSL are undergoing assessment to determine whether they should be declared toxic under the Act. Regulations will be prepared for those that are declared toxic. The report of the NO_x/VOC Work Group on Effects contains an analysis of the health effects of several selected VOCs.

American studies of cancer risks in urban areas due to exposure to toxic VOCs show that ~70% of the exposure was due to emissions from road vehicles and to photochemically generated formaldehyde (Lahre 1988). As long as a reduction of one type of VOC does not result in increases in other equally or more toxic VOCs, reduction in VOC emissions for the purpose of reducing tropospheric ozone levels will have the additional benefit of reducing human exposure to toxic air pollutants.

Stratospheric Ozone Layer Depletion

Chlorofluorocarbons (CFCs), which are the primary contributor to stratospheric ozone level depletion, are VOCs. They are, however, long-lived, low reactivity VOCs and make no significant contribution to the formation of tropospheric ozone. Probable CFC substitutes, such as hydro chlorofluorocarbons (HCFCs), might give cause for concern, as these have higher reactivity and greater tropospheric ozone-forming potential than the CFCs currently being used. No estimate has been made of the significance of this substitution to ozone formation in the future.

Global Warming

The VOCs involved significantly in global warming are CFCs and methane, estimated to contribute 13% and 18%, respectively, to the greenhouse effect. The Plan is not likely to have any significant benefits or disbenefits regarding methane emissions.

TABLE 2 VOLATILE ORGANIC COMPOUNDS ON THE CEPA PRIORITY SUBSTANCES LIST (DANN 1989)

GROUP 1:	(Assessment within 3 Years)
	Benzene
	Methyl Tertiary-butyl ether
GROUP 2:	(Assessment within 4 Years)
	Chlorobenzene
	1,2-Dicholorobenzene
	1,4-Dichlorobenzene
	1,2-Dichloroethane
	Dichloromethane
	Styrene
	1,1,2,2-Tetrachlorethane
	Tetrachloroethylene
	Toluene
	Trichlorobenzenes
	1,1,1-Trichloroethane
	Trichloroethylene
	Xylenes
GROUP 3:	(Assessment within 5 Years)
	methyl methacrylate
	bis (2-Chloroethyl) ether
	bis (Chloromethyl) ether

III PRE-PLAN NO_x AND VOC EMISSIONS

III.1 Emission Forecasts and Assumptions

Current (1985) and projected (to 2005) emissions of NO_x and VOCs are provided both nationally and provincially in Appendix A. This emission forecast, referred to as NO_x/VOC Emission Forecast 90-B, is the emission data set upon which the plan is based.

Summary information from Emission Forecast 90-B is presented in Tables 3 and 4 and Figures 11 to 14. Tables 3 and 4 list the 1985 and 2005 national emission values and the percentage change between these years. Figures 11 and 12 show the general source categories and projected NO_x and VOC emissions in each category nationally for the period 1985 to 2005. Figures 13 and 14 show the distribution of NO_x and VOC emissions among provinces for each of 3 selected years - 1985, 1995 and 2005.

Assumptions and information sources used in developing Forecast 90-B are described in Appendix A and in the report of the Work Group on NO_x/VOC Emission Inventories. Some of the key information sources used are:

- National Energy Board (NEB) estimates of car and truck stock growth rates (NEB 1988),
- NEB estimates of energy demand for all energy related sectors by fuel type and by province/territory (NEB 1988),
- Informetrica economic and population growth estimates for other sectors (by sector and by province/territory),
- Electricity demand growth rates and fuel mixes provided by provincial power utilities, and
- Provincial base year (1985) emission data.

Emission Forecast 90-B is based on the current level of control for all source categories. For example, the motor vehicle emission projections take into account the effect of the existing (1987) tailpipe standards (1.0 g/mi for NO_x, 0.41 g/mi for hydrocarbons) over the 1985 to 2005 time period. They do not account for any of the measures announced by CCME in October, 1989 for future application of tighter tailpipe standards, fuel volatility reduction, or inspection and maintenance programs. Similarly emissions from gasoline marketing and distribution assume the status quo, and do not account for the effect of implementing Stage 1 vapour recovery in some regions as announced by CCME in October, 1989.

Factors other than emission controls can change emission rates over time. Adjustments have been made for the following:

- The rate of importation into Canada of heavy duty vehicle engines designed to meet the tighter U.S. NO_x standard of 5 g/BHP-hr after 1991 (without any change in the Canadian standard of 6 g/BHP hr).
- The effect of Ontario Hydro's demand side management (DSM) program (accounted for in Ontario electricity demand forecasts). No other utility DSM programs have been accounted for.

TABLE 3 NO_x EMISSIONS IN 1985 AND 2005 AND PERCENTAGE CHANGE

	NO_x EMISSIONS (kt)		
Source	1985	2005	% Change
Mobile			
On-Road Vehicles	739.3	500.0	-32
Off-Road Vehicles	260.5	346.2	+33
Railroads	132.1	113.0	-14
Aircraft	33.4	42.3	+27
Marine	14.9	18.5	+24
Total Mobile	1180.2	1020.0	-14
Stationary			
Power Generation	247.9	351.7	+42
Natural Gas	158.8	205.2	-29
Other Industrial Fuel Combustion	119.4	178.9	+50
Commercial Fuel Combustion	25.8	28.4	+10
Residential Fuel Combustion	41.5	36.9	-11
Industrial Processes	89.0	139.7	+57
Incineration/Misc.	24.3	34.6	+42
Total Stationary	706.7	975.4	+38
Total	1886.9	1995.4	+ 6

TABLE 4 VOC EMISSIONS IN 1985 AND 2005 AND PERCENTAGE CHANGE

	VOC Emissions (kt)		
Source	1985	2005	% Change
Mobile			
On-Road Vehicles	613.6	401.7	-35
Off-Road Vehicles	90.7	108.6	+20
Marine	27.9	31.5	+13
Aircraft	10.1	13.2	+31
Railroads	7.0	6.0	-14
Total Mobile	749.3	561.0	-25
Stationary			
Solvent Use	502.0	602.9	+20
Industrial Processes	142.0	239.4	+58
Fuelwood Combustion	107.7	132.7	+23
Slash Burning	80.6	129.0	+60
Gasoline Distribution	109.0	124.4	+14
Industrial Fuel Combustion	49.5	63.9	+29
Other	32.0	38.6	+21
Total Stationary	1034.1	1330.9	+29
Total	1782.4	1891.9	+6

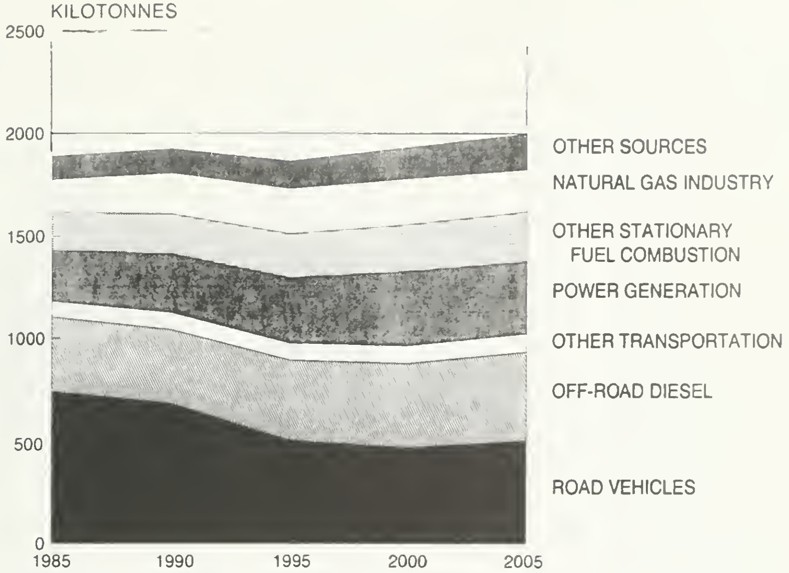


FIGURE 11 NATIONAL NO_x EMISSIONS PROJECTIONS — 1985 TO 2005

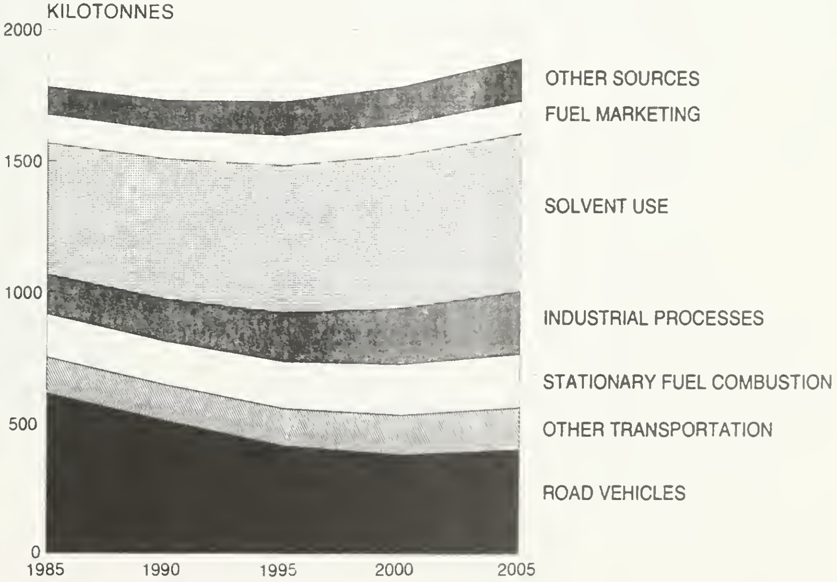


FIGURE 12 NATIONAL VOC EMISSIONS PROJECTIONS — 1985-2005

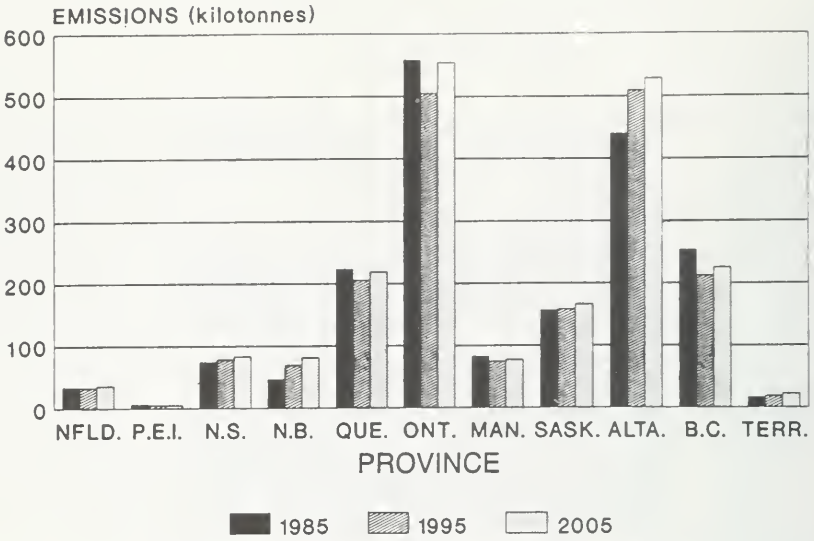


FIGURE 13 PROVINCIAL DISTRIBUTION OF NO_x EMISSIONS

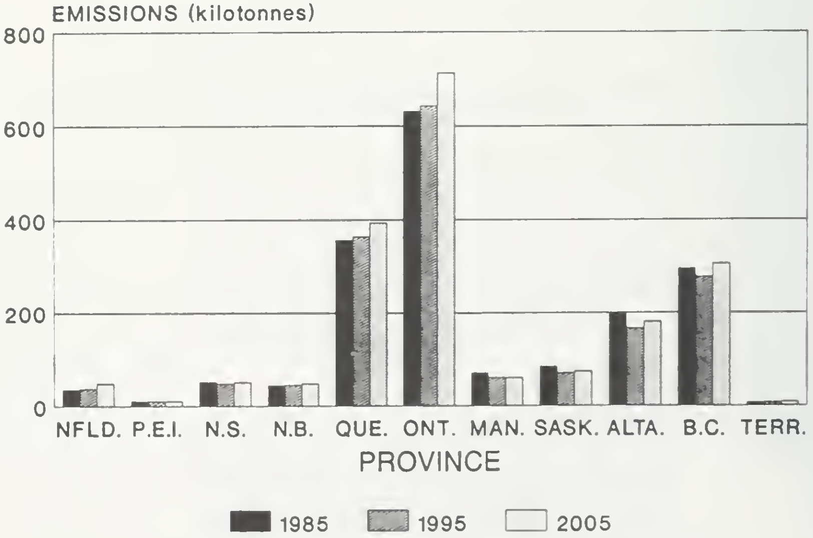


FIGURE 14 PROVINCIAL DISTRIBUTION OF VOC EMISSIONS

- Changes in rail transport systems including replacement of diesel locomotives (at the rate of 40 per year starting in 1995), operational improvements and reduced passenger service.

Motor vehicle emissions have been calculated using a Canadianized version of the recently acquired MOBILE 4C model developed by the U.S. Environmental Protection Agency (NO_x/VOC Workgroups on Emission Inventories and Control Technologies 1990). MOBILE 4C computes both tailpipe and running loss emissions from motor vehicles, and accounts for factors such as tampering rates, fuel volatility and ambient temperatures.

For some sectors, the lack of information on the extent of controls currently being applied required that "no control" emission factors be used. Examples are VOC controls in the plastics processing industry and in many of the solvent use industry categories.

It should be recognized that any emission forecast involves many assumptions regarding such things as economic growth, emission regulations, rate of implementation of emission controls, mixes of energy generation types, influence of energy conservation and product substitution initiatives, and other factors. Emission Forecast 90-B represents the best current estimate of present and future emissions. It is a snapshot in time, with full recognition that it will need to be updated regularly during the life of the Plan. Future editions of the Plan will no doubt reflect the most recent forecast available at the time of preparation.

It should be noted that there is substantial evidence that current anthropogenic VOC emission estimates are too low, and that true emissions may be higher by a factor of two to three (Pierson 1990). Underestimation of emissions from the mobile source category is likely the major reason for discrepancies between inventory estimates of VOC emissions and field derived estimates (Pierson 1990).

III.2 Observations on Emission Trends and Sectoral Contributions

Several general observations from the Forecast 90-B emission projections for NO_x and VOCs are made below.

a) Nitrogen Oxide Emissions

1. NO_x emissions nationally in 2005 are projected to be 6% higher than current (1985) levels. They have increased by about 2% between 1985 and 1990 and are expected to decline slightly over the next 5 years, reaching a level in 1995 about 3% below the 1985 level. After 1995, overall emissions begin an upward trend which presists to 2005 and beyond.

2. The reduction in emissions in the near term is due to a sharp decline in both light duty and heavy duty vehicle emissions between 1990 and 1995, combined with modest reductions in emissions from rail transport. The combined reductions more than offset emission increases in other source categories.

3. By 1995, the effectiveness of the current motor vehicle emission standards in reducing emissions will for the most part have been realized as new

vehicles come to dominate the motor vehicle population. Motor vehicle emissions level off beyond 1995 as the growing vehicle population offsets further reductions resulting from the current standards.

4. With the levelling off of motor vehicle emissions after 1995, the increasing emissions in other sectors due to continuing growth in population and industrial activity cause NO_x emissions nationally to begin a slow but sustained increase to 2005 and beyond.

5. The sectors with the largest projected increases in NO_x emissions are industrial boilers and heaters (50%), industrial processes (57%) and power generation (42%). Although total mobile source emissions decrease, emissions from off-road vehicles (mainly diesel), a major source category, increase by 33%.

6. Geographically, NO_x emissions in provinces vary slightly from the national trend of an increase in NO_x emissions of 6% by 2005. B.C. and Manitoba will undergo 11% and 9% decreases, respectively. Ontario, Quebec and PEI emissions return approximately to current levels, after a drop in the mid-1990s. Increases greater than 6% will occur in other provinces, with the highest percentage increases in Alberta (20%) and New Brunswick (74%).

b) Volatile Organic Compounds (VOCs)

1) VOC emissions nationally in year 2005 will be 6% above the current (1985) level. A level 3% below the 1985 level is projected for the early 1990s followed by a gradual and sustained increase to 2005.

2) As with NO_x emissions, the rapid decline in VOC emissions from motor vehicles in the near term offsets gradually increasing emissions in most other sectors. However, motor vehicles contribute a smaller percentage to total VOC emissions than they do to total NO_x emissions. Because of this, the decline in emissions is more quickly overtaken by the presistent stationary source increases. VOC emissions nationally drop between 1985 and 1990 and appear to have already bottomed out in the early 1990s. Without further control, an accelerating rate of increase is anticipated to 2005 and beyond.

3) Sectors contributing most to the increase in VOC emissions nationally are plastics processing (116% increase), crude oil production (89% increase) organic chemical plants (41% increase), other industrial processes (73% increase), surface coating (35% increase) and slash burning (60% increase).

4) By 2005, solvent use is projected to be the largest single VOC source category, contributing 32% of all VOC emissions, compared to 21% from light duty vehicles and 7% from fuelwood combustion, the next largest source categories. VOC emissions from solvents in 2005 will, in fact, be greater than VOC emissions from all mobile sources combined.

5) Solvent use can be divided into numerous subcategories, the largest being paints and coatings. Others include glues and adhesives, printing, dry cleaning, auto care and maintenance products, household and personal care products, and numerous other solvent uses. A breakdown of VOC emissions in the various subcategories is provided in the report of the NO_x/VOC Work Group an Control Technologies, Sub-Group 6.4.

IV PRINCIPLES AND APPROACH

IV.1 Principles for Allocating Emission Reductions

Through the multi-stakeholder consultation process undertaken as part of the Plan development program, a set of principles for allocating NO_x and VOC reductions were developed for use as a guide in preparing the Plan.

These principles are contained in report of the NO_x/VOC Work Group on Principles of Apportionment, but are repeated here because they provide fundamental guidance on the scope and content of the Plan. They are presented "verbatum" as follows:

1. Solutions to Real Problems

The Management Plan should be aimed at solving or preventing real environmental and human health problems, rather than at responding to arbitrary criteria.

In particular, it should deal with the following environmental protection priorities by targeting compliance in Canada with relevant National or Provincial Air Quality Criteria.

The Environmental Protection Priorities are:

1) Human Health,
2) Urban Air Quality,
3) Rural Air Quality, and
4) Meeting International Environmental Protection Obligations
   e.g. NO_x freeze domestically
   e.g. NO_x freeze for Transborder Flows

2. Effectiveness

The Management Plan should allocate reductions based on their environmental and economic effectiveness. Ideally an allocation based on effectiveness would allocate reductions to those sources with the lowest cost of reduction per unit of improvement in air quality.

Since it is very difficult to quantify such a measure, allocation to the sources with the lowest cost per tonne of reduction may be the best alternative. The cost element is composed of the direct cost of the reduction technology plus any secondary economic impacts of implementing the reductions, such as the loss of markets, or in the case of transportation, shifts between transportation modes.

In terms of environmental effectiveness, the following factors should be considered:

. Whether the reduction solves more than one environmental problem.
. The performance of the controls over their lifetime of operation, not just when they are new.
. The secondary impacts caused if restrictions on one sector cause growth in another one, which could result in a shift in emissions rather than a reduction.

. Seasonality considerations.
. New pollution generated in the production, installation or operation of technology or management approaches aimed at reducing NO_x or VOC.
. Whether emission rate reductions can be compared on an equivalent basis within an economic or industrial sector.

3. A Phased Approach

The Management Plan should combine short, medium and long term strategies so as to obtain a continuous improvement aimed at solving or preventing real problems. The timeline and commitments to reductions should be made public.

The timing of control actions should recognize the development of new technologies, the turnover of existing plants and equipment, the type of use made of existing plants and equipment, and opportunities provided by modifications which need to be made to existing plant and equipment. Thus, the allocation of reductions would take advantage of the opportunities which are available to facilitate reductions.

Included in a phased approach would be opportunities for "mid-course corrections" to be made to the Management Plan should the need arise.

4. Policy Instruments

The Management Plan should consider the full range of policy instruments available. However, the choice of instruments should not influence the allocation of reductions, but rather it (the choice) should be made after the reductions have been allocated. Reductions should not be allocated to sources because they can be controlled by a favoured policy instrument.

5. Coordination

The allocation of reductions in the Management Plan should take into account other control strategies or approaches as well as existing and proposed regulations. Harmonization of federal and provincial regulation to avoid duplication and contradictions is also desirable.

6. Flexibility of Response

The method of allocation, and the resulting reduction requirements, should not restrict innovation or the flexibility to respond to changing conditions. In this regard, performance criteria are preferred to specified technologies.

7. Common Baseline

All control opportunities should be independently evaluated relative to a common baseline. Emissions in the baseline year should not serve as a basis for the allocation of reductions among sectors although it may be appropriate for national and international reporting. The allocation should accommodate actions being taken for other environmental problems.

8. Comprehensiveness

The Management Plan should allocate to all relevant sectors, as defined by their contribution to the ozone problem. Sectors which might have more difficulty in implementing reductions should be allowed more time (see Principle #3, A Phased Approach) and/or special assistance in technology transfer, but should not be exempted from undertaking their share of reductions.

9. Prevention

The Management Plan should recognize that in order to prevent deterioration of air quality, national guidelines governing emissions from new sources should be prepared. These could be incorporated into regulation by provincial governments, which would also be able to impose more stringent requirements for the regions which require them. This approach would not exclude national standards if they are judged to be appropriate.

10. A Regionally Based Approach

The Management Plan should, as a first step in the allocation of reductions, attempt to find regional solutions to regional problems. Should these fail to meet national or international commitments, further reductions should then be sought.

11. A Broad Approach

The Management Plan should be broadly based, so that solutions to environmental problems do not create or compound other environmental problems. The Plan should take advantage of synergistic opportunities.

12. Econometric Models

Since the Management Plan will attempt to solve health and environmental problems, the use of econometric models or techniques to assess the impacts of the Plan should also attempt to assess the value of health and environmental improvements.

IV. 2 Approach to Preparing the Management Plan

The key steps followed in preparing the Management Plan were as follows:

1. The regions with the most serious ozone problems were examined in terms of:

    i) the magnitude, geographic distribution and source types of NO_x and VOC emissions within the region;

    ii) the reduction in ozone levels needed to achieve attainment with the maximum acceptable ozone concentration of 82 ppb;

    iii) where possible, the relationship between the geographic distribution of NO_x and VOC sources and the pattern of elevated ozone concentrations;

iv) the relative effect of local versus imported pollutants on the ozone pattern in the region; and

v) the probable effectiveness of NO_x versus VOC reductions at Canadian sources.

2. An evaluation was made of the NO_x and VOC reductions achievable nationally in the year 2005, and in selected regional settings by implementing a set of nationally applicable initiatives:

    i) a realistic set of energy efficiency and demand management measures (consistent with the anticipated thrust of control programs for greenhouse gases);

    ii) a realistic set of product reformulation or substitution targets for products containing solvents;

    iii) new source performance standards, based on state-of-the-art technology, for new mobile and stationary source sectors of NO_x and VOCs which contribute significantly to current ozone problems and/or are projected to have significant growth in emissions with potential to cause future ozone problems where none now exist (consistent with the above listed principles of allocation and with the terms of the international NO_x protocol); and

    iv) public education initiatives to increase public awareness and public contribution to the solution.

3. Additional control measures were successively applied to existing NO_x and VOC emission sources in regions where ozone problems would obviously still remain after implementing the above measures nationally (or where new ozone problem areas might have been created because the national initiatives had not prevented significant increases in NO_x and VOC emissions from occurring).

    The control measures considered for region-specific application included a full range of options: emission control technologies, energy efficiency measures, demand management measures, product control and public education. Due consideration was given to cost effectiveness, the relative contribution of the source to the ozone problem and potential effects on industry and consumers.

4. A comprehensive set of NO_x and VOC reduction initiatives was developed, incorporating both national and regional measures. These initiatives, along with the accompanying schedule and mechanism for implementation, constitutes the Management Plan.

V REGIONAL ANALYSES OF EMISSION REDUCTION REQUIREMENTS

V.1 Relationship Between VOC/NO_x Emission Reduction and Reduction in Ozone Concentrations

Before examining specific regional situations, it is useful to discuss the ozone formation process and ozone-precursor relationships. The following section briefly outlines some of the current state of knowledge of the relationship between NO_x and VOC emissions and ozone formation.

Ozone Formation Process

The formation of ozone in the troposphere is primarily controlled by three reactions. In the first reaction, NO_2, in the presence of sunlight, dissociates to form nitric oxide and a single oxygen atom.

$$NO_2 + hv \xrightarrow{K1} NO + O \quad (1)$$

The single oxygen atom reacts with atmospheric oxygen to form O_3.

$$O + O_2 \longrightarrow O_3 \quad (2)$$

A third reaction acts continuously to destroy ozone and regenerate NO_2.

$$NO + O_3 \xrightarrow{K2} NO_2 + O_2 \quad (3)$$

The steady-state concentration of ozone at a particular site depends on the following equation (Dodge, 1987):

$$[O_3] = \frac{K_1}{K_2} \times ([NO_2]/[NO]) \quad (K_1, K_2 \text{ are rate constants})$$

The ratio (K_1/K_2) is determined primarily by the intensity of sunlight; it has a value of zero at night. In contrast, the ratio of NO_2/NO is sensitive to the presence of VOC, because these species are sources of free radicals which can oxidize NO to NO_2.

Ozone formation is said to be NO_x-limited when addition of NO_x results in higher ozone concentrations. However, the NO_x-limited condition is a function not only of NO_x, but also of the VOC concentration. The situation is illustrated in Figure 15, which plots O_3 as a function of NO_x with VOC as a parameter. The figure shows that O_3 increases as NO_x rises until O_3 reaches a maximum, decreasing thereafter with further increases in NO_x. Whether ozone increases or decreases with increasing NO_x is determined by the VOC/NO_x ratio. The figure shows that for VOC/NO_x ratios greater than about 4.8, ozone will be in the NO_x-limited condition, and vice versa. The precise VOC/NO_x ratio that forms the boundary of the NO_x-limited region will vary depending on the type of hydrocarbons involved (the curves in Figure 15 are for a mixture of propylene and n-butane), so no special significance attaches to the ratio of 4.8. Nevertheless, atmospheric values of VOC/NO_x $>$ 10 generally lead to NO_x-limited conditions for O_3 formation. Thus, a high VOC/NO_x ratio is a necessary condition for ozone to be in the NO_x-limited region. Observations of VOC/NO_x ratios and mean VOC/NO_x concentrations at Canadian urban and rural sites are given in Table 5.

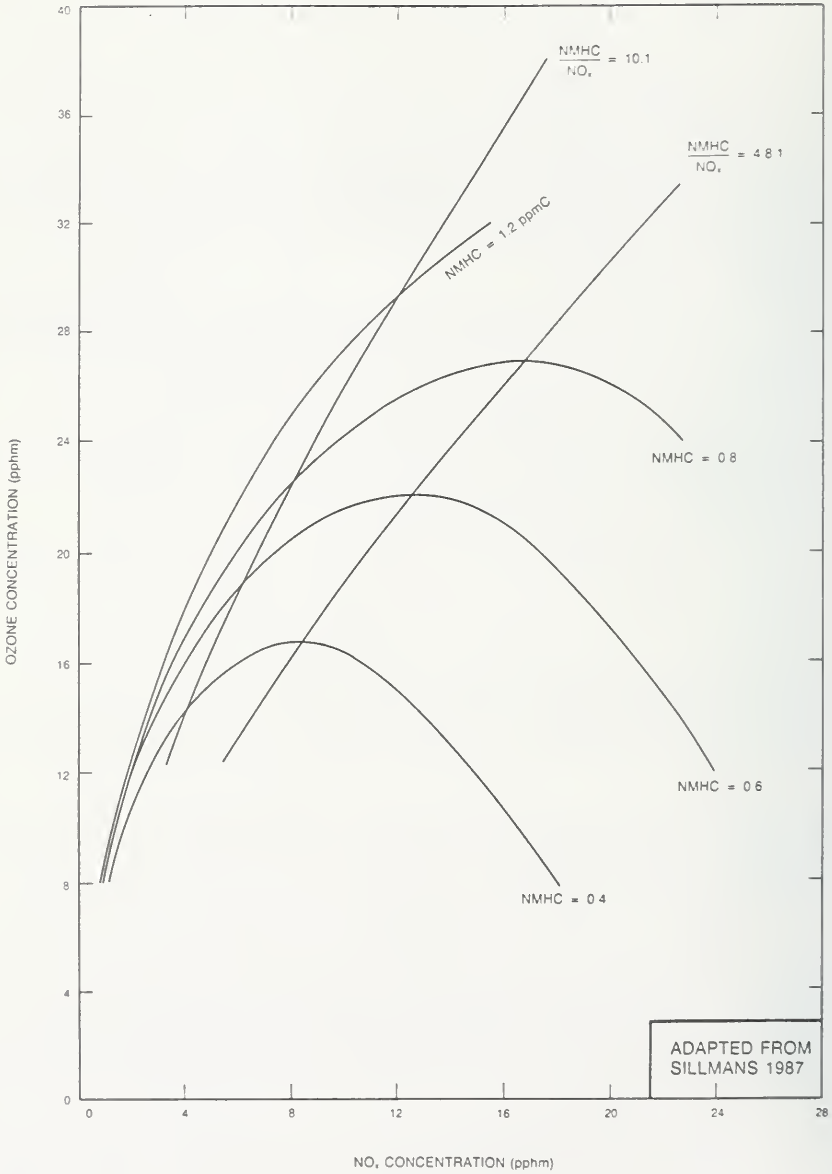


FIGURE 15 OZONE CONCENTRATION AS A FUNCTION OF NO_x LEVEL WITH NONMETHANE (NMHC) AS PARAMETER

TABLE 5 RATIOS OF NON-METHANE VOCs TO NO_X

City	VOC/NOx Med.	Max.	Min.	Mean VOC (ppbC)	Mean NOx (ppb)	Sampling Dates	No. of Samples	Reference
URBAN								
Toronto 1 (Queen's Park)	9.5	12.7	8.3	702	67	July-Oct. 1987	9	Dann, 1989a
Stouffville 1	17.3	34.1	10.9	380	20	July-Oct. 1987	16	Dann, Personal Communication
Hamilton 2	7.5	11.2	3.3	325	41	April-June 1989	9	Dann, Personal Communication
Sarnia	15.1	76.5	3.4	---	---	-----	---	Reid/Wong, 1988
Sarnia 2	6.4	11.4	3.2	154	23	April-May 1989	7	Dann, Personal Communication
Windsor 2	9.7	41.6	4.1	400	48	July-Dec. 1987	20	Dann, 1989a
	10.3	26.6	4.6	382	33	April-May 1989	7	Dann, Personal Communication
Montreal -Ontario St. 2	8.7	27.5	2.4	416	47	April-June 1989	8	Dann, Personal Communication
Pte. aux Trembles 2	11.9	14.5	7.3	332	31	April-June 1989	7	Dann, Personal Communications
Vancouver -Burnaby South 3	11.8	16.1	4.0	410	53	Aug.-Oct. 1987	9	Dann, 1988a
-Burnaby South 4	6.9	14.5	5.6	321	64	Aug.-Dec. 1988	10	Dann, 1989c
Vancouver -Burnaby North 3	15.1	63.8	3.5	931	75	Aug.-Oct. 1987	23	Dann, 1989a
Vancouver -Kitsilano 4	4.4	5.0	3.6	193	53	Aug.-Dec. 1989	5	Dann, 1989c
Vancouver 2 -Rocky Point Park	6.8	9.5	5.9	353	63	March-April 1989	9	Dann, Personal Communication
Rural								
Walpole Island 2	---	---	---	198	--	Jan.-Sept. 88		
Dorset/Egbert 5		7-->40		32	1-4	Aug. 88		

1. Samples Collected 6-9 am or 7-10 am
2. 24 hour sampling once every six days
3. Samples Collected 3-7 am or 6-9 pm
4. Samples collected 6-9 am
5. Instantaneous samples collected in July/Aug. 1989

VOC and NO_x levels and subsequent VOC/NO_x ratios can vary from ozone episode to episode, from city to city and across urban areas. As polluted air masses are transported, chemical and physical processes remove NO_x more rapidly than VOCs resulting in an increase in VOC/NO_x ratios. NO_x reductions generally become more effective in reducing ozone concentrations downwind of high emission regions over suburban and rural areas.

Ozone-Precursor Relationships

General

The complexity of the atmospheric processes resulting in ozone formation cannot be overstated. The complexities stem from the fact that ozone is an extremely reactive pollutant and can be scavenged by the same pollutants (i.e. NO, some VOC) that produce it (Dimitriades 1988). Theoretically, relationships between ozone and its precursors can be derived from laboratory smog chambers, from urban and regional scale photochemical models, from field monitoring studies and from empirical multi-year historical data relating emission trends to observed changes in ozone. In practice, due to severe limitations in empirical evidence, most accepted ozone to precursor relationships are derived form modelling evidence (Dimitriades 1988). Modelling evidence in turn is affected by the accuracy of chemical/transport mechanisms used to simulate the real atmosphere, the accuracy of ambient precursor concentration data, the accuracy of emission data and the adequacy of treatment of transport of ozone and precursors. Some details of existing models and results of model scenarios are contained in the report of the NO_x/VOC Workgroup on Modelling.

Urban Modelling

Most urban modelling results are based on the Empirical Kinetic Modelling Approach (EKMA) and have focussed almost exclusively on VOC reduction as a control technique. EKMA is considered most appropriate for isolated urban areas with simple topography, uniform emission distributions and moderate ozone problems. Some examples of relationships between percentage VOC reduction and percentage ozone reductions derived from EKMA are given in Tables 6 and 7.

Most EKMA results would suggest that VOC reductions are more beneficial than NO_x reductions at ambient VOC/NO_x ratios $< 8:1$. However, EKMA results show that a reduction in either or both NO_x and VOCs will reduce peak ozone levels.

More sophisticated urban models include the Urban Airshed Model (UAM) developed by Systems Application Inc. of the U.S. This is a grid based model (grids are normally 5 X 5 km) and has been applied in the New York City area, in Los Angeles, and in Europe. Some recent results of control strategy effects based on UAM application in U.S. cities are shown in Table 8 (Scheffe 1990). The UAM has been proposed as the model of choice for the LFV airshed. (Bennett 1990).

TABLE 6 PEAK OZONE VS PRECURSOR REDUCTIONS AT DIFFERENT VOC/NO$_x$ RATIOS (FRIEDMAN ET AL 1988)

VOC/NOx Ratio	Emission Reduction	Reduction in Peak O3
Low	- 35% VOC - 35% VOC, - 35% NOx	- 26% - 20%
Medium	- 35% VOC - 35% VOC, - 35% NOx	- 13% - 20%
High	- 35% VOC - 35% VOC, - 35% NOx	- 9% - 20%

TABLE 7 ESTIMATED OZONE REDUCTIONS FROM ONE PERCENT REDUCTION IN VOLATILE ORGANIC CARBONS EMISSIONS FOR SELECTED CITIES IN THE U.S.A.* (PRATAPAS AND CALCAGNI 1983)

City	% O3 Reduction / % VOC Reduction
Boston, MA	0.7
New York, NY (NY-NJ-CT)	0.9
Philadelphia, PA (PA-NJ-DE)	0.8
Baltimore, MD	0.7
Washington, DC (DC-MD-VA)	0.9
Houston, TX	1.4
St. Louis, MO	0.7
Salt Lake City, UT	0.8
Los Angeles, CA	0.9
Fresno, CA	0.8
Ventura, CA	0.7
San Diego, CA	1.1

* From SIP design data. Modeling parameters current as of April 21, 1983; emission inventory current as of February, 1983.

TABLE 8 CONTROL STRAGEGY EVALUATIONS BASED ON URBAN AIRSHED MODEL (SCHEFFE 1990)

City	% Red. VOCs	% Red. NOx	% Red. Peak O3
Dallas-Ft. Worth	-30% -24%	0% -40%	-32% -24%
St.Louis	-24%	-25%	-36%
Atlanta	-30% -18%	0% -32%	-19% -24%

Regional Scale Models

The U.S. EPA Regional Oxidants Model (ROM) has been the most extensively applied regional model. Southern Ontario is included in the model domain. Numerous runs of ROM have been carried out to evaluate the effectiveness of VOC, NO_x and combined VOC/NO_x strategies. Some of the results are shown in Table 9. Results from ROM suggest that VOC reduction will reduce peak ozone levels in the areas with highest ozone concentrations. NO_x controls are effective at reducing ozone concentrations across the northeast and throughout Ontario. A combined VOC/NO_x reduction program results in the largest overall reduction in ozone with the exception of the New York metropolitan area where NO_x controls appear to be counter-productive (Posseil 1990, US EPA 1986, Lamb 1987). ROM results suggest that very large emission reductions (>60%) would be required to reduce ozone levels below the U.S. primary standard of 120 ppb in northeastern North America (NO_x/VOC Workgroup on Modelling).

Regional models have also been applied Europe. Northern Europe experiences ozone maxima similar to those recorded in the WQC. As shown in Table 10, the Eurpoean modelling effort suggests that combined VOC/NO_x reduction would result in the largest ozone reductions. Emission reductions of greater than 75% VOC and 75% NO_x would be required to reduce peak ozone below 80 ppb in all areas of northern Europe based on model results. (FRG 1989, Zierock 1988)

Rural Models/Transport of Ozone

The Regional Oxidant Model has shown that the bulk of the ozone attributable to anthropogenic sources is generated within about 100 km of the major urban areas, and that beyond distances of about 200 km, ozone is primarily in a state of decay (EPA 1986, Lamb 1987). Most areas of the eastern United States, including rural areas, were shown to be net exporters of ozone due to local generation of ozone. This local generation of ozone is due to imported and locally produced precursor species.

Harvard University has developed a model with the capability of predicting ozone levels in rural areas (Sillman et al 1987). The model has been applied to the northeastern U.S. and to southern Ontario and indicates that concentrations of precursor in rural air are sufficient to produce significant levels of photochemical oxidants. Rural ozone appears to be generated from the interaction of anthropogenic hydrocarbons and anthropogenic NO_x and from biogenic hydrocarbons and anthropogenic NO_x. Relationships between O_3 and precursors determined by the model in a three day simulation are shown in Figure 16. The results show that with rural NO_x levels below 1 ppb, production of O_3 will be small even if substantial amounts of hydrocarbon are present. Under these conditions, elevated O_3 levels can only occur as a result of transport from urban areas. However, at higher levels of NO_x, substantial O_3 concentrations can be generated at modest levels of hydrocarbons. Observations in August, 1988, at two sites north of Toronto, Egbert and Dorset, showed that anthropogenic VOC concentrations averaged ~30 ppbC and NO_x (NO_2) averaged of 2-5 ppb. In the eastern U.S., rural NO_x concentrations are typically greater than 1 ppb and rural anthropogenic VOC concentratons range from 20 to 100 ppbC (Sillman et al 1987).

TABLE 9 RESULTS FROM REGIONAL OXIDANTS MODEL (ROM) SCENARIOS (NO_x/VOC WORKGROUP ON MODELLING)

ROM Scenario	Reduction in number of Cells > 120 ppb (Washington, NY, Conn., Boston)
VOC -20%, NOx - 2%	-28 to -41%
VOC -56%, NOx - 2%	-65 to -71%
VOC -49%, NOx -33%	-73 to -95%

(% Reduction in peak concentrations not available)

TABLE 10 RESULTS FOR SAI REGIONAL OZONE MODEL APPLIED TO NORTHERN EUROPE (FRG AND NETHERLANDS 1989)

PHOXA AREA	No. of Grid Hours O_3 (ppb) > 60	>80	>100	>120	PEAK OZONE
	Reduction in Grid Hours >96h simulation				
BASE	24,445 (34.6%)	9406 (13.1%)	1964 (2.8%)	62 (0.1%)	113 to 128 ppb
Max VOCs - 48% VOCs - 24% NO_x	(-2%)	(-12%)	(-32%)	(-81%)	% Reduction in Peak Ozone - 4 to - 7%
Max NO_x - 54% NO_x - 18% VOCs	(-5%)	(-33%)	(-67%)	(-100%)	- 10 to - 23%
Max NO_x & Max VOCs - 54% NO_x - 48% VOCs	(-8%)	(-40%)	(-75%)	(-100%)	- 11 to - 24%

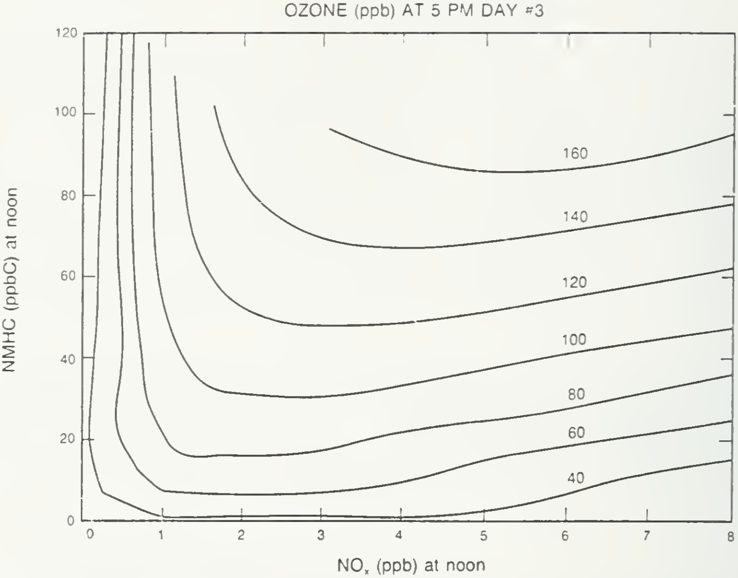


FIGURE 16 RURAL SENSITIVITY STUDY: OZONE VERSUS NO$_x$ AND ANTHROPOGENIC NMHC CONCENTRATIONS WITH NO ISOPRENE EMISSIONS (SILLMAN ET AL 1987)

Both the ROM and Harvard results suggest that episodes of high O_3 in eastern North America can develop, fuelled by photochemical production form precursors present in rural air. Because of much lower NO_x emission densities, this process appears to be unlikely in most western rural areas.

A regional model of NO_x for eastern North America predicts annual average NO_x ($NO + NO_2$) levels in most of eastern Canada in the range of 8-12 ppb (Fay et al 1987). The model also suggests that significant transport of NO_2 can occur in the atmosphere, and that concentrations of NO_2 in most areas of eastern Canada are due to distant sources.

SUMMARY

1. Reductions in maximum ozone concentrations will usually be less than proportional to reductions in VOC and/or NO_x emissions.

2. For most situations, VOC reductions will reduce peak concentrations near major source areas. Effectiveness is a function of VOC/NO_x ratio, VOC/NO_x concentrations and meteorology. In most situations, the highest ozone concentration will occur during mid-afternoon about 50 km downwind of source areas.

3. Ozone production in rural areas of eastern Canada appears to be NO_x limited. Models show that reductions in NO_x will reduce ozone on a regional scale throughout the northeast. However, very large reductions in regional NO_x emissions (>70%) may be needed to consistently attain the 82 ppb standard throughout southern Ontario and southern Quebec.

4. Simultaneous reduction of VOCs and NO_x appears to be the best startegy to achieve the goal of zero hours >82 ppb and reduce other problems associated with VOCs and NO_x.

5. Additional modelling on both the urban and regional scale should be undertaken as soon as possible to verify the impact of proposed emission reductions and to determine the need for additional controls.

V.2 Regional Analyses

Three geographic regions were analyzed for (i) reductions needed to achieve attainment of the Canadian maximum acceptable ozone objective of 82 ppb, (ii) magnitude and areal distribution of NO_x and VOC sources, (iii) influence of imported pollutants, and (iv) possible merits of NO_x versus VOC control. The regions analyzed were:

- Lower Fraser Valley (LFV)
- Windsor-Quebec Corridor (WQC)
- Southern Atlantic Region (SAR)

a) Lower Fraser Valley Region

Size and Location

This region consists of four census divisions:

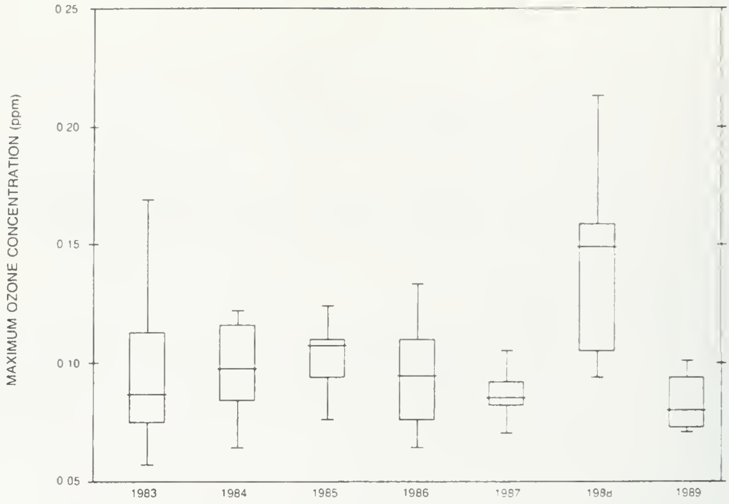
-Greater Vancouver Regional District (GVRD)
Central Fraser Valley Regional District
Dewdney-Allouette Regional District
Fraser-Cheam Regional District

The total population of the region is 1.53 million, 53% of the population of British Columbia.

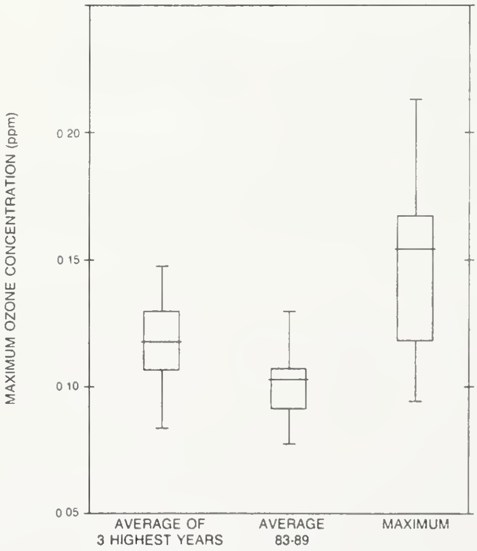
Extent of Problem

Monitoring results show that the western portion of the GVRD and the area to the south of Vancouver (Richmond, Delta) have rarely experienced ozone levels greater than 82 ppb (see Figure 5). The highest ozone concentrations in the region occur at the eastern end of the Burrard Inlet although relatively high concentrations (>120 ppb) occur at most monitoring sites along the Fraser River as far east as Chilliwack.

Some of the highest hourly maximum ozone counts for the country have been measured in the LFV, although occurrence of levels >82 ppb are much less frequent than in the WQC (See Figure 3). Boxplots of maximum ozone and hours >82 ppb by year for all eastern and rural (Fraser Valley) GVRD sites are given in Figures 17 and 18. As shown in Figures 17 and 18 there is substantial year to year variability in the occurrence of peak ozone; most sites recorded the highest maximum ozone values and the highest hours >82 ppb in 1988. Analysis of earlier monitoring data has shown that ozone episodes were much more frequent in the GVRD during the years 1980-81 than they are at present (Dann, 1988). Figure 17(b) shows the



(a) MAXIMUM OZONE BY YEAR



(b) DISTRIBUTION OF SITE MAXIMUM OZONE

BOXPLOT PLOTTING CONVENTIONS

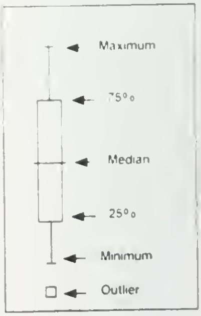


FIGURE 17 MAXIMUM OZONE — EAST GVRD AND LOWER FRASER VALLEY (1983-1989)

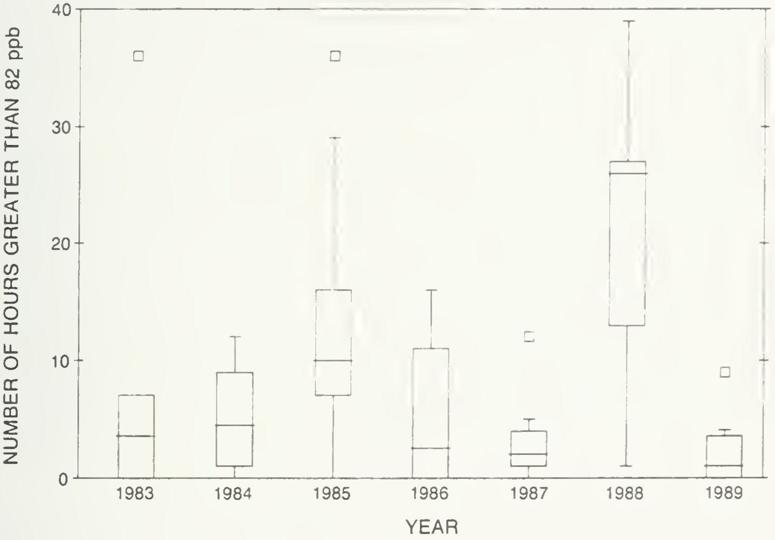


FIGURE 18 OZONE HOURS >82 ppb — EAST GVRD AND LOWER FRASER VALLEY

distribution of site maximum ozone for the average of the three highest years, for the average of all years between 1983-1989, and for the highest year in the period. For the worst case situation, reductions in ozone of >50% would be required to achieve the 82 ppb standard at 75% of the sites; the highest site would require a 60% reduction in ozone. Using the average of the three highest years, a reduction of 40% in peak ozone would be required to achieve the 82 ppb level at 75% of the sites. Although ozone peaks decline eastward through the valley, a 25% reduction in peak ozone would still be required as far east as Chilliwack in order to meet the 82 ppb air quality objective.

Meteorology/Transport

Ozone episodes in the LFV appear to be associated with the formation of a sea breeze, resulting in low mixing heights and channelling of GVRD emissions eastward up the Burrard Inlet (Davis et al 1984, Concord and Levelton 1989). High inland temperatures, clear skies and stagnant weather systems are a common meteorological feature of episodes.

The LFV shares a common airshed with parts of the state of Washington to the south. One analysis of ozone episodes (Coligado 1988) has suggested that precursor and ozone transport from the Puget Sound area of Washington state might influence the LFV airshed. It is unlikely, however, that long range transport is a significant contributor to the very high peak ozone levels measured at times in the Port Moody area.

VOC/NO_x Observations

A substantial amount of 24 hour, 3 hour and 6 hour VOC and NO_x data has been collected in the GVRD, although most of it was collected for purposes other than ozone control strategy formulation (see Table 6). Median VOC/NO_x ratios measured at GVRD sites were variable, and ranged from 4 to 15.

Modelling Results

The only modelling results available for the LFV are from a limited EKMA analysis carried out under contract in 1988 (Concord and Levelton 1989). The results indicated that a VOC control strategy would be the most optimum approach for reducing peak ozone levels in the GVRD. Because of the limitations involved in applying EKMA to an airshed as complicated as the LFV and because of inadequacies in input data for the model runs, these results should be treated with caution.

Emissions

Emissions of NO_x and VOCs in the LFV region in 1985 and projections for 2005 are estimated as follows:

	Emissions (KT) 1985	 2005	 % Change
NO_x			
Mobile	73.1	45.3	-38%
Stationary	19.6	22.5	+15%
Total	92.7	67.8	-27%
VOC			
Mobile	61.4	43.8	-29%
Stationary	52.6	61.1	+16%
Total	114.0	104.9	-8%

The relatively high percentage reductions in NO_x emissions from mobile sources more than offset increases in stationary source emissions. However, despite significant reductions in VOC emissions from mobile sources, only modest overall VOC reductions occur, due to offsetting increases in stationary source emissions. Examination of the source data indicates that the increase in stationary source NO_x is due primarily to industrial processes and industrial fuel combustion. The increase in VOC emissions is due primarily to industrial processes and solvents. In 2005, the largest sources of NO_x and VOCs, ranked in order of contribution to total emissions, are projected to be:

NO_x Emissions

Source Category	KT/yr	% of Total
LDV/LDT	16.5	24.3
HDV	16.1	23.8
Ind. Fuel Comb.	10.7	15.8
Offroad Diesel	8.1	12.0
Refinery Process	2.1	3.1
Res. Fuel Comb.	1.8	2.7
Marine	1.6	2.3
Comm. Fuel Comb.	1.5	2.2
Railroads	1.3	1.9
Power Generation	1.2	1.8
Offroad Gas	1.1	1.6
Kraft Pulp	0.9	1.3
Other Misc.	4.9	7.2
	67.8	100.0

VOC Emissions

Source Category	KT/yr	% of Total
LDV/LDT	26.7	25.5
Paints/Coatings	13.4	12.8
Gen. Solvent	10.0	9.5
Marine	6.5	6.2
Gas Distribution	6.1	5.8
Ind. Fuel Comb.	5.6	5.3
Cons. Prod. Solv.	3.8	3.6
Refinery Process	3.6	3.4
HDV	3.2	3.1
Offroad Gas	3.0	2.9
Fuelwood	2.7	2.6
Adhesives	2.1	2.0
Plastics Process	1.6	1.5
Printing	1.2	1.1
Ind. Degrease	1.1	1.0
Dry Cleaning	0.9	0.9
Other/Misc.	13.4	100.0
	104.9	100.0

Required Emission Reductions

In the absence of definitive model results, and based on the discussion in Section V.1 and results of modelling efforts in other airsheds, it is anticipated that combined NO_x and VOC reductions would be most effective in reducing peak ozone concentrations in the GVRD and downwind areas of the Fraser Valley. Because the import of NO_x and VOCs into the region should have limited impact on the highest concentration sites, it is assumed that percentage reductions in NO_x and VOC emissions will result in equivalent percentage reductions in ambient air concentrations of NO_x and VOCs. These in turn will result in less than a one to one reduction in ozone. Imported NOx and VOCs may be affecting the eastern portion of the Lower Fraser Valley, and domestic NOx/VOC reductions may not result in equivalent percentage reductions in ambient air NOx/VOC levels in this area.

Given these assumptions, the following NO_x and VOC reductions would be needed to bring typical peak O_3 levels in the LFV region consistently down to 82 ppb:

i) 50-60% reduction in VOCs
No reduction in NO_x
ii) 50-80% reduction in NO_x
No reduction in VOCs
iii) 40-50% reduction in VOCs
40-60% reduction in NO_x

To reduce worse case peak ozone levels to 82 ppb, even larger percentage reductions will be required. It should be noted that due to the complex topography of the area and limited spatial scale of the most heavily impacted area, greater emission reductions may be needed in some areas of the GVRD than in others. A high resolution model will be required to determine the benefits of emission reductions targetted by location.

b) Windsor-Quebec Corridor (WQC)

Size and Location

The WQC region, for the purpose of this analysis, represents a narrow strip of land (about 100 km wide) along the north shores of Lake Erie, Lake Ontario and the St. Lawrence River in Quebec, and continuing along both sides of the St. Lawrence River from the Ontario border to Quebec City in Quebec. The region included is outlined in Figure 19, which also shows the major VOC and NO_x-source areas near the Great Lakes. The WQC region contains 85% (7,757,000) of Ontario's population and 64% (4,183,000) of Quebec's population.

Extent of Ozone Problem

Figure 20 shows a profile of maximum ozone concentrations and hours >82 ppb along the corridor, superimposed on bar graph displays of NO_x and VOC emissions in 1985. Box plots showing the variation in maximum ozone and hours greater than 82 ppb by year for the 50 monitoring sites in southern Ontario/southern Quebec are shown in Figures 21 and 22. The year 1988 was a particularly severe ozone year, with most sites recording the highest maximum ozone and the greatest number of hours over 82 ppb in the period 1983-1989. In Figure 21(b), the distribution of site maximum ozone is shown for three cases: (a) the average of the three highest years; (b) the average of all years 1983-1989 and; (c) the highest maximum recorded in the 7 year period. For the worst case, to achieve the 82 ppb concentration at 75% of the sites, a reduction in peak ozone of 50% would be required with the worst site requiring a 55% reduction. Using the average of the three highest years (i.e., a typical high ozone year) reductions of 45 to 50% are required for the worst sites and reductions of at least 20% at the "cleanest" sites.

Meteorology/Transport

Occurrences of high ozone in the WQC are strongly associated with periods of high temperatures. Figure 23 shows a plot of number of days with maximum temperatures greater than 32°C vs average maximum ozone and average hours>82 ppb for 31 sites in southern Ontario for the period 1983-1989. For

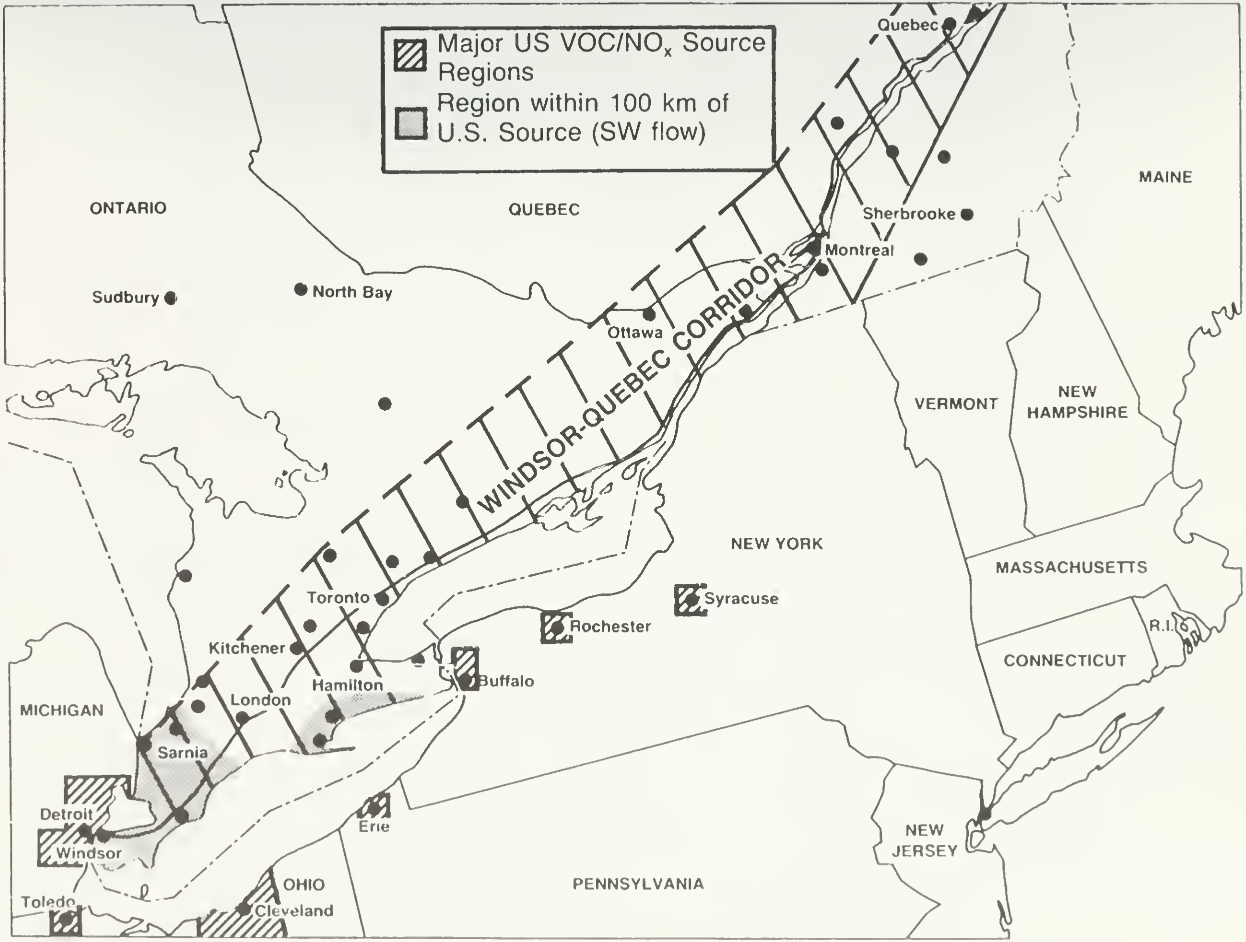


FIGURE 19 WINDSOR-QUEBEC CORRIDOR AND LOCATION OF MAJOR U.S. VOC/NO$_x$ SOURCE REGIONS NEAR THE GREAT LAKES

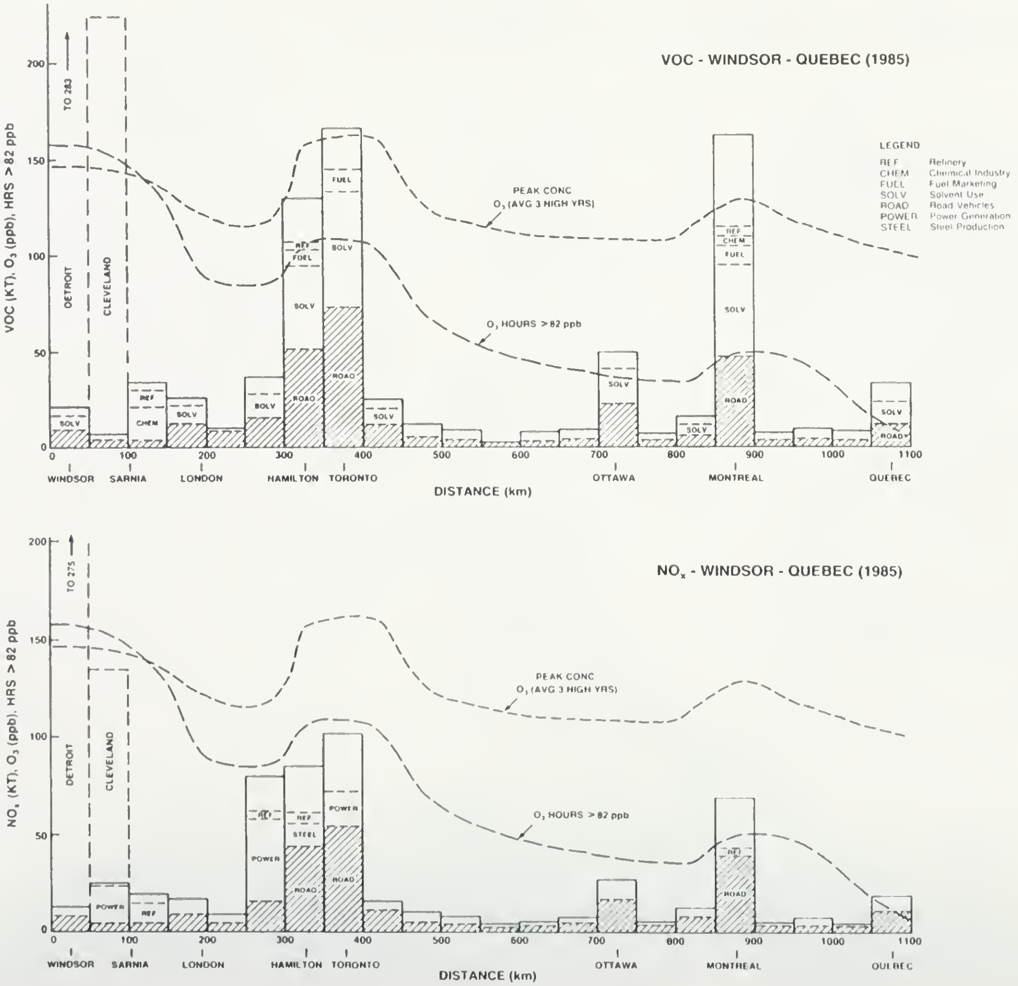
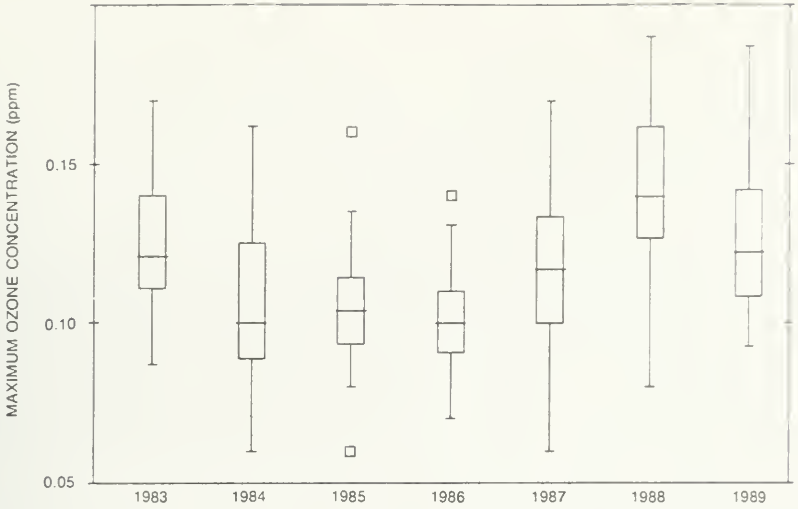
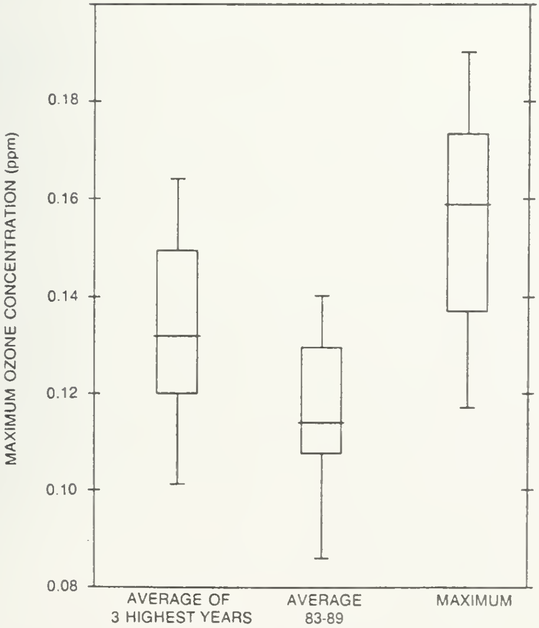
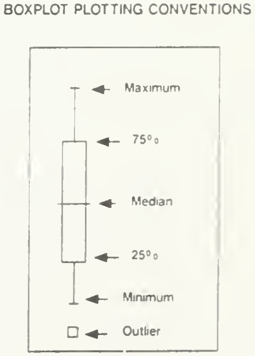


FIGURE 20 OZONE PROFILE AND NO$_x$/VOC EMISSIONS ALONG THE WINDSOR-QUEBEC CORRIDOR (WQC)



(a) MAXIMUM OZONE BY YEAR





(b) DISTRIBUTION OF SITE MAXIMUM OZONE

FIGURE 21 MAXIMUM OZONE CONCENTRATIONS (1983-89) IN WINDSOR-QUEBEC CORRIDOR

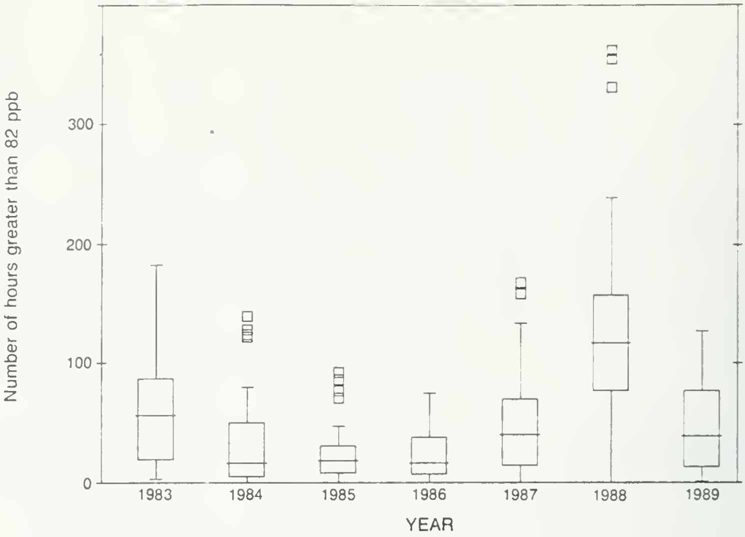


FIGURE 22 OZONE HOURS >82 ppb — WINDSOR-QUEBEC CORRIDOR

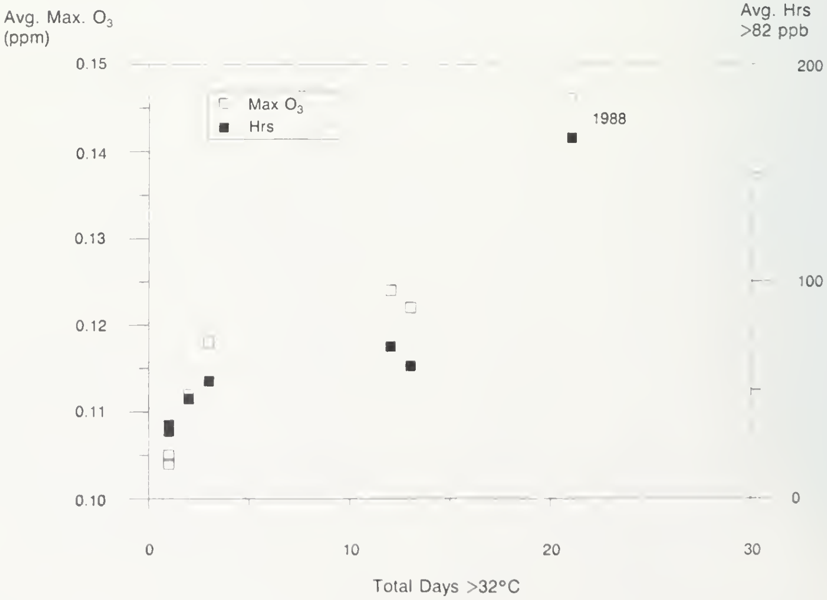


FIGURE 23 RELATIONSHIP BETWEEN DAYS WITH MAX. TEMP. >32°C AND AVG. MAX. 03/DAYS >82 ppb — ONTARIO (1983-89)

Toronto, the number of days >32°C is typically about 6 based on 1950-1988 meteorological records, whereas the year 1988 had 21 days with maximum temperature >32°C and 13 days with maximum temperature >34°C. In turn, high temperature days in the WQC are associated with stagnating high pressure systems that maintain clear skies and high temperatures (see Section II.3(d)). These weather systems result in predominently southwesterly flows through the region.

A number of areas in southern Ontario are close to major U.S. emission sources, and during southwesterly flow could be within the high ozone plumes associated with these areas (see Figure 19). Back trajectories for 28 episode days occurring in Ontario between 1987 and 1989 show that in all cases air parcels had passed over Michigan and/or Ohio within 6 to 12h of their arrival at London, Ontario (midway between Toronto and Windsor). Apart from direct ozone impacts, in rural areas of Ontario increases in precursor concentrations due to U.S. emissions, especially NO_x, may be very important in rural ozone formation processes.

The Montreal-Quebec area is much further removed from high U.S. emission source regions. Back trajectory analyses of 15 Montreal episodes occurring in 1987, 1988 and June 1989 show that in 5 cases, air parcels arrived from the southwest after passing over Michigan, Hamilton, Toronto and the St. Lawrence Valley. In 4 cases, air parcels carried from south of Lake Ontario, passing through Buffalo and northern New York states. Only in the last 4 cases were travel times from U.S. source regions less than 24 hours.

Figure 24 shows typical back trajectories for ozone episodes in London, Ontario and Montreal, Quebec.

Quantifying the impact of U.S. emissions on Ontario/Quebec ozone levels is very difficult. The impacts would be expected to diminish as one moves eastward through the corridor due to increasing distance from U.S. sources, and the influence of the large VOC/NO_x emissions associated with the Hamilton-Toronto and Montreal urban areas. This tends to be confirmed by the declining profiles of ozone peaks and hours >82ppb in Figure 19.

Some additional observations about the apparent impact of various U.S. and Canadian emission sources on the O_3 profile can be made from Figure 19. At the Windsor end of the corridor, O_3 peaks appear to be almost entirely due to U.S. sources. Fairly large point source VOC emissions at Sarnia cause only a minor bump in the emission profile, and seem to have limited effect on the O_3 profile downwind. On the other hand, Hamilton-Toronto area emissions creat a large bulge in the profile and appear to have a significant effect downwind, probably all the way through to Montreal. A second significant bulge is created in the profile at Montreal, from which residual effects appear to carry downwind to Quebec City and beyond.

Peak ozone levels in southeastern Ontario and along Lake Erie and Lake Huron are undoubtedly due almost entirely to U.S. emissions.

VOC/NO_x Observations

A limited data base of urban VOC and NO_x measurements is available for the WQC; median VOC/NO_x ratios range from 6.4 to 17.3 at urban sites. Limited rural data for VOC is available for two sites only (see Table 6).

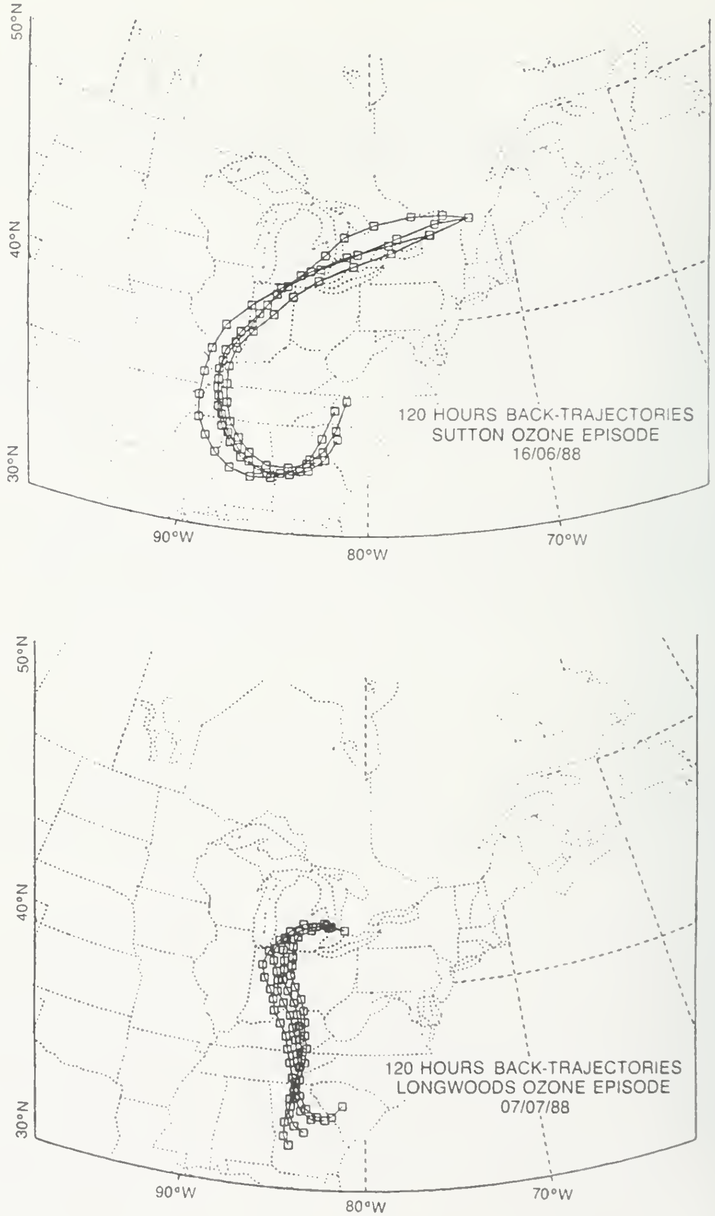


FIGURE 24 BACK TRAJECTORIES FOR OZONE EPISODES IN THE WINDSOR-QUEBEC CORRIDOR

Very few observations of rural NO_x are available, although as discussed in Section V.1, rural NO_x levels are probably high enough to result in local generation of ozone throughout the corridor.

Modelling Results

Results for ROM showed a limited impact in Ontario of U.S. VOC emission reductions (U.S. EPA 1986, Fay et al 1987). Some reductions in peak ozone in southeastern Ontario would result, due to reduced VOC emissions in the Detroit and Cleveland areas. Scenarios involving large regional reductions in NO_x showed significant benefits in reducing ozone concentrations in southern Ontario.

Some emission reduction scenarios have been carried out using the ADOM model. Results from this model suggested little benefit from Ontario emission reductions of VOCs, and the greatest benefit from U.S. NO_x emission reductions (NO_x/VOC Workgroup on Modelling). Because the model was not been fully evaluated and because of the very coarse resolution of the model, these results should be treated with caution.

Emissions

Emissions of NO_x and VOCs in the WQC in 1985 and and projections for 2005 are estimated as follows:

	Emissions (KT)		
	1985	2005	% Change
NO_x			
-mobile	363.9	308.2	-15%
-stationary	208.3	256.5	+23%
Total	572.2	564.7	-1%
VOC			
-mobile	291.8	233.8	-20%
-stationary	465.3	606.6	+30%
Total	757.1	840.4	+11%

Most of the NO_x stationary source emission increase comes from industrial fuel combustion and industrial processes. The largest contributors to the increase in stationary source VOCs are solvents (45% of increase) and industrial processes (32% of increase). The remainder is distributed among many sources ranging from gasoline distribution to fuelwood combustion. The largest NO_x and VOC sources in the WQC in 2005, ranked in order of contribution to total emissions, are estimated to be:

NO_x Emissions

Source Category	KT/yr	% of Total
LDV/LDT	111.1	19.7
HDV	97.1	17.2
Power Generation	93.4	16.5
Ind. Fuel Comb.	70.3	12.4
Offroad Diesel	64.6	11.4
Ind. Processes	55.4	9.8
Res. Fuel Comb.	15.7	2.8
Aircraft	13.0	2.3
Marine	12.5	2.2
Railroads	3.7	0.7
Other	15.6	2.8
	564.7	100.0

VOC Emissions

Source Category	KT/yr	% of Total
LDV/LDT	165.0	19.6
Paints/Coatings	148.2	17.6
Gen. Solvent	94.8	11.3
Fuelwood Comb.	69.5	8.3
Gas Distribution	63.9	7.6
Cons. Prod. Solv.	36.2	4.3
Organic Chem.	31.1	3.7
Refinery Process	28.6	3.4
Offroad Gas	25.7	3.1
Plastics	25.0	3.0
Adhesives	19.6	2.3
HDV	17.1	2.0
Marine	11.9	1.4
Printing	11.2	1.3
Ind. Degrease	9.8	1.2
Dry Cleaning	7.3	0.9
Pulp & Paper	3.5	0.4
Other	72.0	8.6
	840.4	100.0

Required Emission Reductions

With the suspected heavy influence of U.S. emission sources on O_3 levels along the corridor, but lack of specific information on how much of the NO_x, VOCs and O_3 observed in ambient air samples at different locations actually originates from the U.S., estimating the effectiveness of Canadian NO_x and VOC controls is difficult. It is assumed that in the Windsor area, where almost all NO_x, VOCs and O_3 originates from U.S. sources, that Canadian controls will do little to solve the ozone problem. As one moves downwind along the corridor, the control of Canadian NO_x and VOC sources should become increasingly effective. This includes control of Canadian sources of NO_x and VOCs in the Windsor end of corridor which add to the pollutant load in incoming northeasterly flowing air masses from the United States.

Reductions in both NO_x and VOCs are required to reduce peak ozone levels along the corridor during episodes. The VOC reductions may be more effective in immediate urban areas. However, recent analysis for the Detroit area has shown that reducing upwind sources of NO_x, including NO_x from within upwind urban centers, results in lower ozone levels in downwind urban centers by reducing the concentrations of NO_x in ambient air being transported into the downwind urban area. NO_x control is likely to be more effective in rural areas throughout the corridor because of the NO_x-limited conditions.

In order to achieve the 30-50% reductions in ozone peaks needed to meet the 82 ppb air quality objective, combined imported and domestic precursor reductions of 50-75% would be needed along the WQC based on the information in Section V.1. Reductions in imported NO_x and VOCs of 30-50% may occur over time with the U.S. Clean Air Act amendments. Similar reductions from Canadian sources could be a significant step towards resolving peak ozone problems in the WQC.

c) Southern Atlantic Region (SAR)

Size and Location

As noted in Section II, the SAR covers the land areas around the Bay of Fundy including southern New Brunswick and western Nova Scotia. For the purpose of estimating emission reduction potential, a segment of the SAR, the Saint John Area (SJA) was selected. The SJA is represented by two counties in southern New Brunswick, Saint John County and Kings County, with a combined population of 139,058 (20% of New Brunswick).

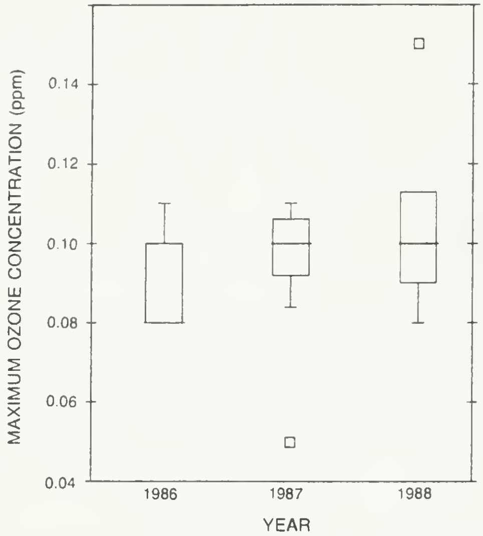
Extent of Ozone Problem

For the years 1986 to 1988, ozone maxima and total hours greater than 82 ppb are shown for nine monitoring sites in southern New Brunswick and western Nova Scotia in Figures 25 and 26. Ozone data for two sites in Halifax and for two sites in Saint John are available for 1983 to 1985 (see Appendix D), but the 1984/85 data for Saint John may not be valid. As shown in Figure 25(b), there is a narrow range of ozone maxima; most sites would require a reduction in peak ozone of 20-25% to reach the 82 ppb level. The highest peak ozone concentration of 150 ppb was measured at Kejimkujik National Park in 1988.

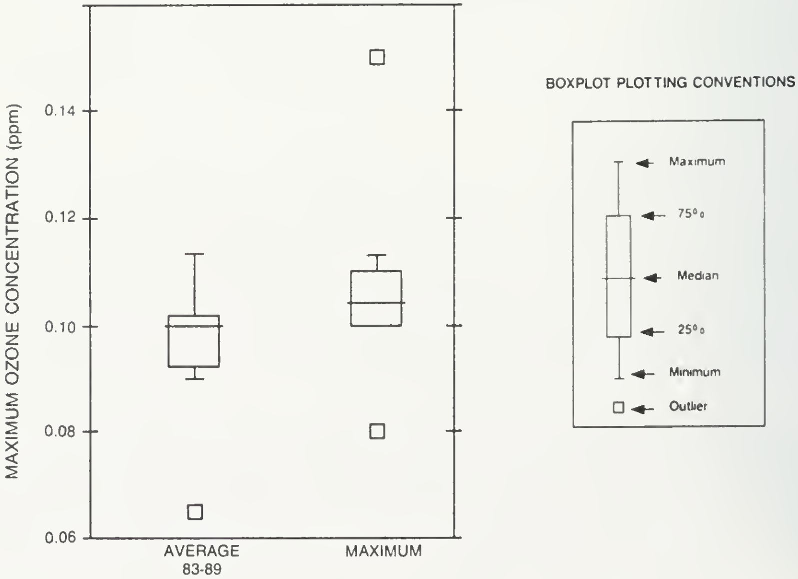
Meteorology/Transport

Meteorological conditions associated with ozone episodes in the SAR are similar to those for episodes in the WQC, i.e., a high pressure system to the east over the Atlantic Ocean and a low pressure system inland to the northwest (see Figure 9). Surface flow is generally from the southwest on the backside of the high pressure cell, transporting ozone and precursors from New England (CCME 1989, Concord 1984, C&P 1987). Analyses of ozone episodes in coastal Maine have shown a similar influence of New England (especially Boston) emissions on peak ozone levels (Burkhart 1990).

Back trajectory analyses for sites in Atlantic Canada show that air masses usually pass over the Atlantic Ocean before reaching the area. The trajectory in Figure 27 for an ozone episode in Saint John, New Brunswick shows that air flows would have passed over the WQC as well as large emission source areas along the eastern seaboard in the U.S. before reaching Saint John, with part of the flow path over the ocean. Ozone concentrations tend to decrease slowly for transport over the ocean as deposition, NO_x



(a) MAXIMUM OZONE BY YEAR



(b) DISTRIBUTION OF SITE MAXIMUM OZONE

FIGURE 25 MAXIMUM OZONE CONCENTRATIONS IN SOUTHERN ATLANTIC REGION (1983-89)

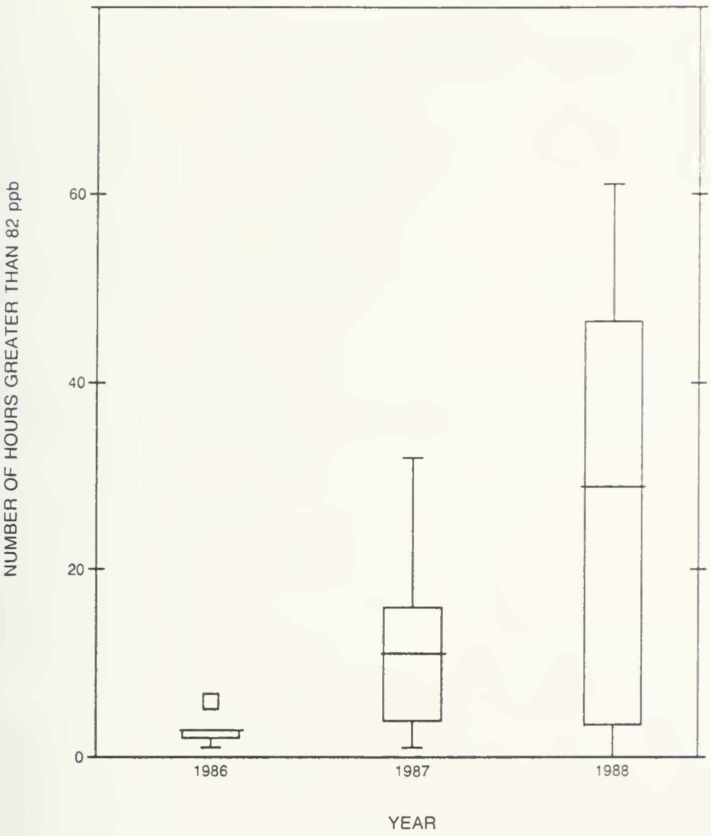


FIGURE 26 OZONE HOURS 82 ppb — SOUTHERN ATLANTIC REGION

scavenging, and dispersion all tend to be less important than for transport over land. When an air mass reaches the coast, it will likely experience mechanical mixing due to the abrupt change in surface roughness. Ozone aloft may be brought down to the surface, even at night. A number of nocturnal peaks in ozone concentration have been reported at southern Atlantic stations (Concord 1984).

The observational evidence does not support the occurrence of significant urban plumes from the cities of Saint John or Halifax.

VOC/NO_x Observations

There is a very limited data base on ambient air NO_x and no reported observations of VOCs.

Modelling Results

There has been no ozone modelling work done for the Southern Atlantic Region.

Emissions

Emissions of NO_x and VOCs in 1985 and projections for 2005 in the portion of the SAR selected for evaluating emission reduction potential, the Saint John area (SJA), are estimated as follows:

	1985	2005	% Change
NO_x			
- mobile	5.8	5.5	- 5%
- stationary	7.7	22.3	+ 289%
Total	13.5	27.8	+ 206%
VOC			
- mobile	3.7	2.8	- 24%
- stationary	6.8	8.0	+ 18%
Total	10.5	10.8	+ 3%

The large percentage increase in NO_x in the SJA emissions indicated by the numbers is misleading in that 1985 was an abnormally low NO_x emission year, with low production from the major NO_x source, power generation. It is more representative to compare 2005 emissions to 1987 or 1988, when electric power production was back up to typical levels and NO_x emissions from stationary sources in the SJA were about 18 kt/yr. Based on these levels, the stationary source increase to 2005 would be only about 21%.

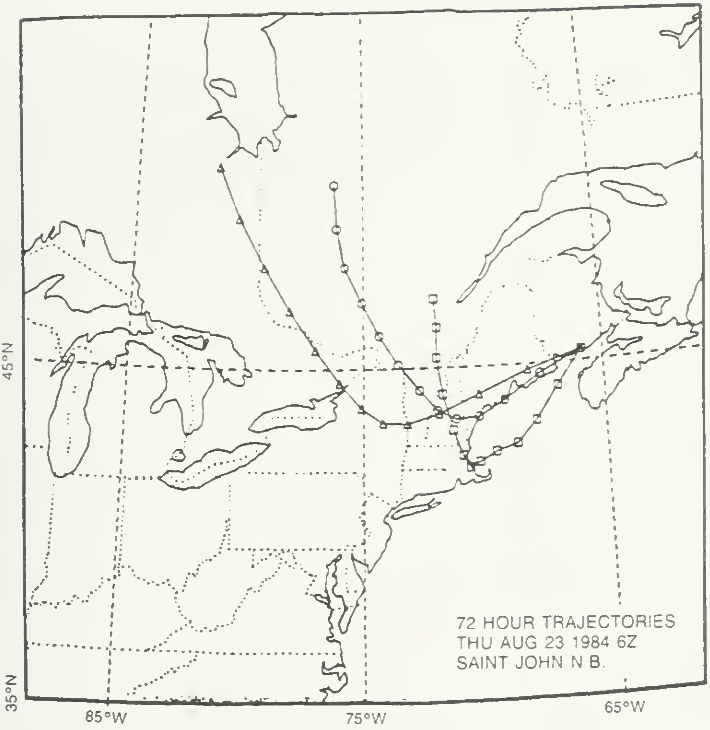


FIGURE 27 BACK TRAJECTORY FOR OZONE EPISODE IN SAINT JOHN, N.B.

The largest sources of NO_x and VOCs in the SJA in 2005, ranked in order of contribution to total emissions, are estimated to be:

NO_x Emissions

Source Category	KT/yr	% of Total
Power Generation	15.7	56.5
Ind. Fuel Comb.	3.7	13.3
Ind. Processes	2.3	8.3
HDVs	2.2	7.9
Offroad Diesel	1.7	6.1
LDV/LDT	1.1	3.9
Railroad	0.3	1.1
Other	0.8	2.9
	27.8	100.0

VOC Emissions

Source Category	KT/yr	% of Total
Fuelwood Comb.	2.4	22.2
Refinery Process	1.6	14.8
LDV/LDT	1.5	13.9
Gen. Solvent	1.2	11.1
Paints/Coatings	0.9	8.4
Gas Distribution	0.7	6.5
Pulp & Paper Proc.	0.5	4.6
HDV	0.4	3.7
Cons. Prod. Solv.	0.4	3.7
Marine	0.3	2.8
Other	0.9	8.3
	10.8	100.0

Required Emission Reductions

Because of the large influence of imported pollutants, NO_x and VOC reductions from sources in the SJA and elsewhere in the SAR will have a limited effect on the magnitude or frequency of ozone peaks. There may be a small additive affect of locally generated ozone that can be reduced by reducing local precursor emissions, particularly from a few large stationary sources of NO_x and VOCs in the SJA.

VI ELEMENTS OF THE PLAN

VI.1 Overview of Three-Phase Approach

The NO_x/VOC Management Plan-Phase I is the first phase of a three-phase program aimed at fully resolving ground-level ozone problems in Canada by 2005. The primary components of each of the three phases are as follows.

Phase I

1. The establishment of a strong prevention program nationally.

2. Interim (1995 and 2000) NO_x and VOC emission reduction targets in designated ozone non-attainment areas, to be negotiated between the federal government and the affected provinces.

3. Studies and investigations to provide the base for establishing final emission caps for ozone non-attainment areas for the years 2000 and 2005.

Phase II (1994)

1. Establishment of final NO_x and VOC emission caps for designated ozone non-attainment areas for the years 2000 and 2005.

2. Indentification of additional remedial measures for ozone non-attainment areas and, if appropriate, extension or tightening of the prevention program, to achieve the caps.

Phase III (1997)

1. Final adjustment to the ozone non-attainment area caps and emission reduction programs.

VI.2 Description of the Phase I Plan

Each of the three primary components of the Phase I Plan are described below.

1. National Prevention Program

The national prevention program consists of a combination of new source performance standards based on best available technology economically achievable, measures for the control of products containing solvents, energy conservation and efficiency measures, and public education.

A starting menu of 31 specific initiatives is defined for the Phase I prevention program, including schedules and identification of jurisdictions responsible for developing and implementing each initiative.

The 31 specific initatives represent the "base" prevention program. It is recognized that there may be other sequencing of control measure development and implementation, other combinations of initiatives, or other methodologies for implementation that would achieve equivalent or better ozone control and perhaps offer advantages in terms of cost effectiveness or preference by implementing jurisdictions. It is also recognized that some of the identified measures are likely to be included in other control programs making their inclusion in this Plan redundant. For example, federal and provincial programs for the control of greenhouse gases are likely to include more agressive energy conservation and efficiency measures than those identified in the Phase I Plan. If the geographic application and timing of the energy conservation and efficiency measures being implemented for greenhouse gas reduction is such that they will reduce ground-level ozone by amounts equivalent to the reductions expected from the measures identified in this Plan, then their application could revert totally to the greenhouse gas programs.

The Phase I Plan provides for substitution of "environmentally equivalent" measures to those specified in the base prevention program. The criteria for determining environmental equivalency are discussed further in Chapter IX, Plan Implementation.

2. Interim (1995 and 2000) Emission Reduction Targets for Ozone Non-Attainment Areas

In subsequent phases of the NO_x/VOC Management Plan, final NO_x and VOC emission caps will be set for the years 2000 and 2005. The 2005 caps will be selected to provide consistent attainment of the 82 ppb ozone objective in all parts of Canada. However, the information currently available on emissions, cause and effect relationships, effectiveness of U.S. control programs, and means available to further reduce emissions beyond the levels identified in Phase I is inadequate for setting final emission caps at this time. Consequently, only interim emission reduction targets will be negotiated as part of the Phase I Plan.

Three regions are designated ozone non-attainment areas for the purpose of establishing interim emission targets for the Phase I Plan. These areas are as follows:

- Lower Fraser Valley
- Windsor-Quebec Corridor
    - Ontario Portion
    - Quebec Portion
- Southern Atlantic Region
    - Saint John Area

The boundaries for the three designated ozone non-attainment areas are as described and as used in estimating emissions for these areas in Chapter V, Regional Analysis of Emission Reduction Requirements.

It is recommended that the interim targets be in the form of percentage reductions in annual emissions of NO_x and VOCs from a specified base year. Uncertainties in the available emission data preclude the establishement of actual reduction tonnages at this time, and the refinement of spatial and temporal scales that will be needed in setting final emission caps.

The interim emission reduction targets will be negotiated between the federal government and the jurisdiction having authority for each designated non-attainment area, and will be contained in joint federal/provincial agreements. They will be achieved by a combination of emission reductions as a result of the national prevention program and the remedial programs to be applied in the non-attainment areas. These remedial programs will be determined by the jurisdictions responsible for the designated non-attainment areas. However, to assist in identifying potential emission reduction options, to provide guidance in setting the interim targets, and to provide a basis for estimating emission reduction potential and costs, an illustrative Phase I NO_x and VOC control program for ozone non-attainment areas was developed and is presented in the following section. This illustrative regional reduction program consists of 27 initiatives for reducing NO_x and VOC emissions, ranging from emission control retrofit on existing emission sources to improved urban transportation management and ozone episode management programs. The jurisdictions responsible may wish to draw upon this illustrative program in establishing the remedial programs that they will be implementing to reach the 1995 and 2000 target reductions. Once jurisdictions have identified their starting or "base" remedial programs these, like the base prevention program, could also be modified throughout the Phase I implementation period to account for new information and changing circumstances, so long as the interim emission reduction targets are met.

The interim annual percentage reduction targets will provide adequate guidance for this first round of emission reductions, provided some fundamental characteristics of ozone episodes and emission variability are taken into account in selecting the measures that will be taken to meet the targets. Particular emphasis should be placed on measures that will reduce summer daytime emissions as well as annual emissions.

It is recommended that the final emission caps for non-attainment areas for 2000 and 2005, to be set in the Phase II Plan in 1994, be in the form of total kilotonnes of NO_x and VOC emissions and have refined spatial and temporal dimensions from those used for the interim reduction targets. Annual targets alone are not appropriate in the long term for managing ozone, which is of most concern during short duration (hours or days) episodic events in summer. Also, in most cases, the areas delineated as non-attainment areas for the interim targets are too large for effective ozone management. In essence the time and spatial dimensions of the caps must be matched to the time and spatial dimensions of the problem.

The probable form of final control criteria for 2000 and 2005 should be borne in mind in implementing the Phase I Plan. It is recommended that the final 2000 and 2005 caps consist of a two tier cap system for ozone non-attainment areas:

- a T/day limit (year round or variable by season, with emphasis on summer)
- a T/year limit

In establishing the daily and annual caps, the following ozone management subareas in the three designated non-attainment areas might be considered:

Lower Fraser Valley	- GVRD - GVRD to Hope
Windsor-Quebec Corridor- Ontario Portion	- Windsor to Ingersoll - Ingersoll to Georgetown - Georgetown to Newcastle - Newcastle to Brockville - Brockville to Quebec Border
- Quebec Portion	- Ontario Border to St.Hyacinthe - St. Hyacinthe to Quebec City
Southern Atlantic Region	- Saint John Area

Other areas, primarily airsheds around the larger urban centres across the country, may also be designated ozone non-attainment areas in the Phase II Plan. This will depend on how effective the Phase I prevention program is in reducing ozone peaks in areas now considered marginal with respect to ozone attainment (i.e., a limited number of exceedances of the 82 ppb objective now occur regularly each year).

3. Studies and Investigations

Additional information is needed in many areas before final NO_x and VOC emission caps can be set for ozone non-attainment areas. For example, the spatial and temporal distribution of emissions from some mobile source categories is not adequately defined. Among these categories are off-road diesel engines, heavy duty vehicles, marine and aircraft. Emission estimates for some mobile and stationary source categories are expected to require significant adjustment over the next year or two as better information is gathered. For example, VOC emissions from motor vehicles are thought to be underestimated by a factor of 2 or 3, and VOC emissions from solvent use sectors may require substantial adjustment when more information on the current level of emission control in these sectors is obtained. Also required is improved knowledge of cause and effect relationships, effectiveness of U.S. control programs in reducing transboundary emission flow, and effectiveness of related federal and provincial programs in reducing NO_x and VOC emissions.

Twenty four (24) study initiatives are outlined as part of the Phase I Plan. These were selected to generate the additional information needed to set final emission caps, design additional emission control programs and track progress towards the interim targets.

VI.3 Summary of Phase I Plan Initiatives

The 31 base prevention program initiatives and the 27 illustrative non-attainment area initiatives under the Phase I Plan are summarized in Tables 11 and 12, which deal with NO_x and VOCs respectively. Studies and investigations for Phase II of the Plan are summarized in Table 13.

For ease of identification and cross referencing, initiatives have been categorized and numbered as follows:

a) NO_x and VOC Emission Control Initiatives (Tables 11 and 12)

National (Prevention) Program	NO_x Control	VOC Control
National energy conservation and product control initiatives.	N101 - N199	V101 - V199
National consumer choice and lifestyle initiatives.	N201 - N299	V201 - V299
National emission source control initiatives.	N301 - N399	V301 - V399
Illustrative Regional (Remedial) Program		
Regional energy conservation and product control initiatives.	N401 - N499	V401 - V499
Regional consumer choice and lifestyle initiatives.	N501 - N599	V501 - V599
Regional emission source control initiatives.	N601 - N699	V601 - V699

b) Studies and Investigations for Phase II of the Plan (Table 13)

S101 - S199	Emission Inventories and Forecasts
S201 - S299	Ambient Air Quality and Modelling
S301 - S399	Technologies, Control Options and Costs
S401 - S499	U.S. Emission Control

The national measures in Tables 11 and 12 represent the base prevention program; the regional measures are illustrative only to permit estimation of reduction potential and costs, and to provide quidance in the setting of interim reduction targets.

In Tables 11 and 12, estimated emission reductions nationally and in each of the selected non-attainment regions are totalled after each successive stage of control. Percentage total reduction below 1985 emissions is also listed at the end of each control stage.

National control initiatives that constitute the prevention program are of two types:

(i) those that would be implemented by the federal government, such as emission limits for mobile sources, energy efficiency standards for equipment and appliances, and product formulation and

(ii) those that would be developed nationally through federal-provincial cooperative programs but implemented by provinces such as new source performance standards for stationary sources of NO_x and VOCs.

TABLE 11 NO_x/VOC MANAGEMENT PLAN - NO_x CONTROL INITIATIVES

Initiative		NO_x Reduction in 2005 (KT)				
		LFV	WQC	SJA[2]	Other[1]	Total
a) National Prevention Program						
Energy Conservation & Product Control (N100 series)						
N101	Electric utility emission reduction targets and action plans based on emission reduction potential from demand side management (DSM), cogeneration and increased purchase of low NO_x alternative energies, by 1992.	0.2	0.0	2.3	36.0	38.5
N102	National energy efficiency performance standards for selected electrical equipment, appliances, motors, lighting, window systems and electrically heated buildings, effective in 1994.					
N103	Energy efficiency performance standards and design guidance documents, and mandatory energy efficiency reporting in permit applications, for selected industrial sectors as specified in schedule A.	1.2	8.3	0.4	10.8	20.7
N104	Voluntary internal energy audits by industry in parallel with environmental audits by 1992.	[No estimate of NO_x reductions]				
N105	New energy efficiency performance standards for fossil fuel heated buildings effective in 1994.	0.2	1.6	<0.1	1.9	3.7
	Subtotal N100 Series	1.6	9.9	2.7	48.7	62.9
	% Difference from 1985	-28.6	-3.0	+85.9[2]	+6.4	+2.4
Consumer Choice and Lifestyle (N200 series)						
N201	Public education campaign to encourage energy conserving driving habits and alternative transportation modes.	[No estimate of NO_x reductions]				

TABLE 11 NO_x/VOC MANAGEMENT PLAN - NO_x CONTROL INITIATIVES (Cont'd)

		NO_x Reduction in 2005 (KT)				
Initiative		LFV	WQC	SJA	Other[1]	Total
Source Control Initiatives (N300 series)						
N202	Public education campaign to encourage voluntary energy conserving habits, product choices and design innovations in homes and businesses.	[No estimate of NO_x reductions]				
	Subtotal N200 Series	--	---	---	---	---
	Accumulative Reduction	1.6	9.9	2.7	48.7	62.9
	Accumulative % Difference from 1985	-28.6	-3.0	+85.9[2]	+6.4	+2.4
N301	New light duty vehicle (LDV) and light duty truck (LDT) NO_x emission standards, fully implemented no later than 1996, of: LDVs 0.4 g/mi LDTs 0.4 or 1.0 g/mi, depending on weight class	4.4	29.9	0.3	29.4	64.0
N302	New heavy duty vehicle (HDV) NO_x emission standards of (i) 5 g/BHP-hr with voluntary compliance in 1991 and regulation effective in 1994 and (ii) 4 g/BHP-hr or lower when another major jurisdiction has imposed an equivalent or tighter standard.	1.3	7.8	0.2	11.6	20.9
N303	NO_x emission standards for diesel engines used in construction when standards for this category have been established by another major jurisdiction.	0.4	3.5	<0.1	4.0	7.9
N304	Cap on NO_x emissions from Canadian rail transport systems at 115 Kt/Yr effective 1992.	[Reductions already in NO_x forecast]				
N305	Successively tighter new source performance standards for NO_x from power plants effective in 1995 and 2000.	---	---	---	25.4	25.4
N306	New source performance standards, effective in 1994, for NO_x from commercial/industrial boilers and heaters.	1.6	17.9	0.4	16.0	35.9
N307	New source performance standards, effective in 1994, for NO_x from stationary combustion turbines.	--	0.4	--	5.9	6.3

TABLE 11 NO_x/VOC MANAGEMENT PLAN - NO_x CONTROL INITIATIVES (Cont'd)

		NO_x Reduction in 2005 (KT)				
Initiative		LFV	WQC	SJA[2]	Other[1]	Total
N308	National adoption of current Alberta NO_x standards for gas-fired reciprocating compressor engines, effective in 1993.	--	---	---	3.0	3.0
	Subtotal N300 Series	7.7	59.5	0.9	95.3	163.4
	Accumulative Reduction	9.3	69.4	3.6	144.0	226.3
	Accumulative % Difference from 1985	-36.9	-13.4	+79.3[2]	-1.4	-6.2
b) Illustrative Regional Remedial Program						
Energy Conservation & Product Control (N400 series)						
N401	Urban transportation management plans designed to reduce NO_x/VOC emissions - all urban centres in LFV and WQC with population greater than 200,000 by 1992 and greater than 100,000 by 1994.	[No estimate of NO_x reduction]				
Consumer Choice and Lifestyle (N500 series)						
N501	Ozone episode management programs in place in the LFV and WQC in all urban centres with population greater than 100,000 and in major NO_x/VOC source areas outside these urban centers, by 1993.	[Reductions during episodes only, no significant annual reduction]				
N502	More effective speed limit enforcement to reduce the average speed of HDVs on major highways in summer by 1993 - LFV and WQC.	0.7	4.4	---	---	5.1
N503	Public education campaigns promoting the environmental benefits of reduced highway speeds in summer by 1993 - LFV and WQC.	[No estimate of NO_x Reduction]				
	Subtotal N500 Series	0.7	4.4	---	---	5.1
	Accumulative Reduction	10.0	73.8	3.6	144.0	231.4
	Accumulative % Difference from 1985	-37.6	-14.2	+79.3[2]	-1.4	-6.5

TABLE 11 NO_x/VOC MANAGEMENT PLAN - NO_x CONTROL INITIATIVES (Cont'd)

Initiative		NO_x Reduction in 2005 (KT)				
		LFV	WQC	SJA	Other[1]	Total
Source Control Initiatives (N600 series)						
N601	Light duty vehicle (LDV) inspection & maintenance (I&M) programs and anti-tampering legislation in the LFV and WQC by 1994.	0.7	4.4	---	---	5.1
N602	Region specific new source performance standards for fossil fuelled power plants for the LFV and WQC effective by 1995, and region specific existing source performance standards for fossil fuelled power plants in the LFV and Ontario portion of the WQC to be effective in 1997.	0.8	57.2	---	---	58.0
N603	Retrofit 50% of existing commercial/industrial boilers and heaters in the LFV and WQC to the NO_x emission levels of the 1994 new source performance standards, by 1997.	0.3	2.8	---	---	3.1
N604	New source performance standards effective in 1995 and a retrofit program for completion by 1997, for NO_x process emissions from iron and steel mills in the WQC.	---	3.2	---	---	3.2
N605	Retrofit refineries in the LFV and WQC to control NO_x process emissions, by 1997.	1.0	6.2	---	---	7.2
	Subtotal N600 Series	2.8	73.8	---	---	76.6
	Total Reduction	12.8	147.6	3.6	144.0	308.0
	Total % Difference from 1985	-40.7	-27.1	+79.3[2]	-1.4	-10.6
	Total Emissions 1985	92.7	572.2	13.5	1208.5	1886.9
	2005 Pre-Plan	67.8	564.7	27.8	1335.1	1995.4
	2005 Post-Plan	55.0	417.1	24.2	1191.1	1687.4

Notes:

[1] Other means rest of Canada

[2] 1985 was an abnormally low NO_x emissions year in the SJA with NOx from power generation (the largest source) only about 30% of the level in 1988. If the 1988 level is referenced, the Plan results in a small reduction in NO_x emissions rather than the high percentage increase obtained by referencing 1985.

TABLE 12 NO_x/VOC MANAGEMENT PLAN - VOC CONTROL INITIATIVES

Initiative		VOC Reduction in 2005 (KT)				
		LFV	WQC	SJA	Other[1]	Total
a) National Prevention Program						
Energy Conservation & Product Control (V100 series)						
V101	Program to reduce VOC emissions from consumer surface coating application by 20% by 1997.	0.7	7.8	<0.1	4.9	13.4
V102	Program to reduce VOC emissions from the use of adhesives and sealants by 40% by 1997.	0.7	7.2	0.1	6.0	14.0
V103	Program to reduce VOC emissions from consumer products (excluding windshield washer and coatings) by 20% by 1997.	0.5	4.6	<0.1	3.9	9.0
V104	Multi-element program to reduce VOC emissions from miscellaneous commercial and industrial solvent use by 20% by the year 2000.	1.5	13.9	0.1	11.5	27.0
	Subtotal V100 Series	3.4	33.5	0.3	26.2	63.4
	% Difference from 1985	-11.0	+6.6	+1.0	+0.9	+2.5
Consumer Choice & Lifestyle (V200 series)						
V201	Public education campaign to encourage energy conserving driving habits and alternative transportation modes (same as N202)	[No estimate of VOC reduction]				
V202	Public education campaign on solvents to (for example): - encourage use of water-base coating - encourage the purchase of alternative consumer products which do not emit VOCs - encourage solvent recovery & recycle - increase industry awareness of concerns and options	[No estimate of VOC reduction]				
	Subtotal V200 Series	---	---	---	---	---
	Accumulative Reduction	3.4	33.5	0.3	26.2	63.4
	Accumulative % Difference from 1985	-7.9	+6.6	+1.0	+0.5	+2.5

TABLE 12 NO_x/VOC MANAGEMENT PLAN - VOC CONTROL INITIATIVES (Cont'd)

Initiative		VOC Reduction in 2005 (KT)				
		LFV	WQC	SJA	Other[1]	Total
Source Control Initiatives (V300 Series)						
V301	New light duty vehicle (LDV) and light duty truck (LDT) VOC emission standards, fully implemented no later than 1996, of: For LDVs 0.25 g/mi For LDTs 0.25 or 0.32 g/mi, depending on weight class.	1.2	7.7	0.1	7.3	16.3
V302	New source performance standard for tanks storing volatile organic liquids, effective in 1993.	0.7	4.9	0.2	2.9	8.8
V303	New source performance standard for process emissions from organic chemical plants, effective 1994.	<0.1	3.1	---	1.8	4.9
V304	Requirement that fugitive emission inventory and leak reduction programs be implemented at new organic chemical plants, effective 1993.	---	2.0	---	1.9	3.9
V305	New source performance standard for plastics processing plants, effective 1995.	0.2	4.4	<0.1	0.6	5.2
V306	New source performance standard for sulphate process in pulp & paper plants, effective 1994.	0.5	0.9	0.1	3.8	5.3
V307	New source performance standard for commercial/industrial coating application facilities, effective 1994.	2.4	25.7	0.2	16.9	45.2
V308	New source performance standards for commercial/industrial printing facilities, effective 1994.	0.3	3.0	<0.1	2.6	5.9
V309	New source performance standard for commercial/industrial degreasing facilities, effective 1995.	0.3	2.3	<0.1	2.0	4.6

TABLE 12 NO_x/VOC MANAGEMENT PLAN - VOC CONTROL INITIATIVES (Cont'd)

		VOC Reduction in 2005 (KT)				
Initiative		LFV	WQC	SJA	Other[1]	Total
V310	New source performance standard and manual on improved operating and maintenance practices for dry cleaning facilities, effective 1995.	0.2	1.5	<0.1	1.3	3.0
	Subtotal V300 Series	5.8	55.5	0.6	41.0	102.9
	Accumulative Reduction	9.2	89.0	0.9	67.2	166.3
	Accumulative % Difference from 1985	-16.1	-0.7	-5.0	-3.6	-3.2
b) Illustrative Regional Remedial Program						
Energy Conservation and Product Control (V400 series)						
V401	Urban transportation management plans designed to reduce VOC emissions - all urban centres in LFV and WQC with populations greater than 200,000 by 1992 and greater than 100,000 by 1994. [Same as N401]	[No estimate of VOC reduction]				
Consumer Choice and Lifestyle (V500 series)						
V501	Ozone episode management programs in place in all urban centres in the LFV and WQC with populations greater than 100,000 by 1993. [Same as N501]	[No estimate of VOC reduction]				
Source Control Initiatives (V600 series)						
V601	Light duty vehicle (LDV) inspection and maintenance (I&M) programs and anti-tampering legislation in the LFV and WQC by 1993 [same as N601]	4.3	26.4	---	---	30.7
V602	Reduction in gasoline volatility in 1992 in LFV, WQC, New Brunswick and Nova Scotia to: 62 kPa RVP for June, July & August 72 kPa RVP for May & September					
	- VOC reduction from motor vehicles	5.3	32.5	0.3	3.1	41.2
	- VOC reduction from gasoline distribution	0.6	6.4	0.1	0.7	7.8

TABLE 12 NO_x/VOC MANAGEMENT PLAN - VOC CONTROL INITIATIVES (Cont'd)

Initiative		VOC Reduction in 2005 (KT)				
		LFV	WQC	SJA	Other[1]	Total
V603	Requirement for vapour balancing and recovery at gasoline storage and transfer depots (bulk and marketing terminals).					
	- New and expanded depots					
	- Vapour balancing and recovery in LFV and WQC, effective 1992	0.4	3.9	---	---	4.3
	- Provision for vapour balancing and recovery everywhere else in Canada, effective 1992	---	---	---	---	---
	- Existing Depots	1.0	9.0	---	---	10.0
	- Vapour balancing and recovery in LFV and WQC by 1993					
V604	Requirement for gasoline delivery vapour balancing at service stations.					
	- New service stations					
	- Vapour balancing in LFV and WQC, effective 1992	0.3	3.1	---	---	3.4
	- Provision for vapour balancing everywhere else in Canada, effective 1992	---	---	---	---	---
	- Existing service stations					
	- Vapour balancing in LFV, WQC by 1993	1.1	10.0	---	---	11.1
V605	Requirement for vehicle refueling vapour balancing at service stations LFV and WQC:					
	- new stations from May 1, 1993	0.6	5.7	---	---	6.3
	- existing stations by December 31, 1995	1.4	13.3	---	---	14.7
V606	Retrofit of tanks storing volatile organic liquids in the LFV, WQC and SJA, to BACTEA by 1994.	1.0	7.6	0.3	---	8.9
V607	Requirement that fugitive emission inventory and leak reduction programs be implemented at petroleum refineries in the LFV, WQC and SJA by 1993.	1.7	13.3	0.8	---	15.8
V608	Retrofit of existing organic chemical plant processes in the LFV and WQC to BACTEA by 1996.	<0.1	5.4	---	---	5.4

TABLE 12 NO_x/VOC MANAGEMENT PLAN - VOC CONTROL INITIATIVES (Cont'd)

Initiative		VOC Reduction in 2005 (KT)				
		LFV	WQC	SJA	Other[1]	Total
V609	Requirement that fugitive emission inventory and leak reduction programs be implemented at existing organic chemical plants in the LFV and WQC, by 1993.	<0.1	2.9	---	---	3.0
V610	Retrofit of existing plastic processing plants in the LFV and WQC to BACTEA by 1996.	0.2	4.0	---	---	4.2
V611	Retrofit of existing sulphate process in pulp & paper plants in the LFV, WQC and SJA to BACTEA by 1997.	0.2	0.7	0.1	---	1.0
V612	Retrofit of existing commercial/industrial surface coating application facilities in the LFV, WQC and SJA to BACTEA by 1996.	3.2	35.1	0.2	---	38.5
V613	Retrofit of existing rotogravure and flexography printers in the LFV and WQC to BACTEA by 1996.	0.6	5.4	---	---	6.0
V614	Retrofit of existing commercial/industrial degreasing operations in the LFV and WQC to BACTEA by 1997.	0.4	3.3	---	----	3.7
V615	Retrofit of existing dry cleaning facilities in the LFV and WQC to BACTEA by 1997.	0.2	1.3	---	---	1.5
V616	Improved emission controls for wood waste burning in the LFV by 1995.	4.0	---	---	---	4.0
	Subtotal V600	26.5	189.4	1.8	3.7	221.5
	Total Reduction	35.7	278.4	2.7	70.9	387.8
	Total % Difference from 1985	-39.6	-25.8	-23.2	-4.0	-15.6
	Total Emissions 1985	114.1	757.1	10.5	900.7	1782.4
	2005 Pre-Plan	104.9	840.4	10.8	935.8	1891.9
	2005 Post-Plan	69.2	562.0	8.1	864.9	1504.1

Note:

[1] Other means rest of Canada

TABLE 13 STUDIES AND INVESTIGATIONS FOR PHASE II OF THE PLAN

Study Initiative		Agencies
Emission Inventories and Forecasts (S100 Series)		
S101	Streamline emission inventories with automated provincial reporting and maximum of 1 year lag time.	Env. Canada All provinces
S102	Update the national emission forecast annually, extending it to 2010, and update historical emission inventory data periodically to account for new information and methodologies.	Env. Canada All provinces
S103	Conduct emission surveys for the pulp and paper, plastics processing and wood transformation sectors.	Env. Canada NB, Que, Ont, BC
S104	Develop a more accurate data base on emissions from products containing solvents (pesticides, general solvent use, etc.).	Env. Canada All provinces
S105	Determine the number and usage rates of off-road vehicles.	Env. Canada
S106	Prepare refined sets of emission inventory data for the WQC with aereal resolution to facilitate oxidants modelling.	Env. Canada Que, Ont
Ambient Air Quality and Modelling (S200 Series)		
S201	Analyze available ambient air monitoring data to obtain additional information on ozone episode characteristics.	Env. Canada NB, Ont, Que, BC
S202	Expand the ambient air monitoring network for NO_x, VOCs and O_3 with emphasis on rural/regional monitoring.	Env. Canada Affected provinces
S203	Obtain better information on the transboundary flow of NO_x, VOCs and O_3 the penetration of these pollutants into various segments of the LFV, WQC and SJA.	Env. Canada NB, Ont, Que, BC
S204	Prepare refined meteorological data sets for the LFV and WQC with aereal resolution to facilitate oxidants modelling.	Env. Canada
S205	Set up and run appropriate scale oxidants models for the LFV and WQC, preferrably with grid sizes for episode modelling not greater than 20 km X 20 km for rural areas or 5 km X 5 km for urban areas.	Env. Canada Ont, Que, BC

TABLE 13 STUDIES AND INVESTIGATIONS FOR PHASE II OF THE PLAN (continued)

Study Initiative		Agencies
S206	Evaluate current information on health effects at different ozone exposure concentrations and times, determine exposure levels in Canada and develop a position on a 6-8 hr ozone standard.	H&W Canada F/P ACAQ
S207	Evaluate current information on ozone damage to vegetation and develop a position on the form and level of an ambient ozone standard to protect vegetation.	Agric. Canada All provinces
Technologies, Control Options and Costs (S300 Series)		
S301	Refine the cost estimates for control of VOC emissions from major sources (organic chemical plants, etc.).	Env. Canada Ont, Alta
S302	Evaluate the type and extent of VOC emission controls currently employed in the plastics, pulp and paper and wood transformation industries.	Env. Canada
S303	Conduct periodic reviews and joint government/industry R&D on advanced combustion and NOx emission control technologies.	Env. Canada EMR
S304	Evaluate the extent of current control and product substitution in all major solvent use categories.	Env. Canada Ont, BC
S305	Evaluate the additional control and product substitution options available for major solvent use categories.	Env. Canada Ont, BC, Cdn. Env. Network
S306	Evaluate measures planned or implemented under the greenhouse gas control program and their implications for NO_x and VOC emissions.	Env. Canada EMR, all provinces Cdn. Env. Network
S307	Analyze Canadian passenger and goods transport networks to determine potential for intermodal shifts on major arteries to reduce CO_2, NO_x and VOCs.	Trans. Canada EMR, Cdn. Env. Network
S308	Evaluate the feasibility and merits with respect to NO_x/VOC reduction of a retrofit building code and labelling program for existing buildings.	EMR All provinces
S309	Evaluate the merits of NO_x/VOC emission trading for ozone control and, if favoured by provinces, develop a model framework for implementation.	Env. Canada, Que, Ont, Alta, BC, Cdn. Env. Network Industry

TABLE 13 STUDIES AND INVESTIGATIONS FOR PHASE II OF THE PLAN (continued)

Study Initiative		Agencies
U.S. Emission Control (S400 Series)		
S401	Analyze the new U.S. NO_x control program for NO_x reductions in selected regions (Ohio Valley, eastern seaboard, etc.) between now and 2010.	Ont, Que, BC Env. Canada Cdn. Env. Network
S402	Analyze measures in, and track implementation of, State Implementation Plans (SIPs) in selected ozone non-attainment areas in the U.S. (Michigan, Ohio, New York, etc.)	Ont, Que, BC Env. Canada Cdn. Env. Network

The illustrative regional control initiatives are largely emission control retrofit programs for existing NO_x and VOC sources; these programs would be developed and implemented by the provinces affected. In some cases, a national guidance document would be prepared for a regional initiative through federal-provincial collaboration to provide consistency of the measure among regions. The illustrative program also includes development of environmentally oriented urban transportation systems and ozone episode management plans.

Of primary consideration in selecting both the national initiatives and the illustrative regional control initiatives for the Phase I Plan were the Principles of Allocating Emission Reductions outlined in Section IV. Most important among these principles is Principle #1: Solving or preventing real environmental and human health problems. The other 11 principles are for the most part conditions, criteria or methodologies for measures designed to meet the primary Plan objectives contained in Principle #1.

Another important factor in selecting the initiatives was the extent to which it was possible or made sense to apply a particular type of control nationally or regionally. For example, energy efficiency, product control and emission controls for many mobile source categories are best dealt with nationally, because of national marketing and distribution, and import/export considerations. To a large degree, new stationary emission sources are also best dealt with in a nationally consistent manner to maintain fairness and equity among regions, firmly establish what the norms for good design and practice are considered to be, and prevent creation of regional pollution havens. Existing source controls, on the other hand, are largely remedial measures needed in regional settings to correct for inadequate prevention measures in the past. They are usually not required on a national scale and involve significant regional cost tradeoffs hence lending themselves best to regional development and implementation.

One of the more important principles considered in selecting both the national and the illustrative regional initiatives was cost-effectiveness (part of Principle #5). In general, there were limits to the degree to which cost-effectiveness could be the primary determining factor in selecting initiatives. In serious ozone problem areas, virtually all control opportunities available, involving a wide range of costs, must be employed. Even then, additional and possibly more costly measures are still needed to fully resolve ozone problems. On the national scale, the large contribution of certain source categories to ozone formation (e.g., motor vehicles) and the need to prevent large projected emission growth rates in certain sectors may override the relatively high cost of control. To the degree possible, flexibility to make cost effectiveness adjustments in the subsequent detailed development of each initiative as the Plan is implemented is built into the initiative descriptions.

The Phase I prevention and illustrative remedial initiatives represent several different types of control (regulatory, public education, transportation planning, episode management, etc.) but do not contain the full range of policy instruments mentioned in Principle #4. Some of the potential policy instruments such as financial incentives and emission trading are not well enough defined at this point in terms of effectiveness, method of application or acceptance by governments or the public to build them in as concrete measures in the Phase I Plan. If in future they become better quantified, implementation methodologies like emission trading might be considered as the bases for remedial programs to be developed by provinces for ozone non-attainment areas. Also, certain kinds of economic incentives and measures such as averaging of vehicle fleet emission standards might prove to be acceptable alternatives to some of the base prevention program initiatives in the Phase I Plan, and be candidates for substitution for prevention initiatives through the environmental equivalency provision. As a minimum, emission trading and other economic instruments will also be studied over the next four years to determine their potential application in the Phase II program.

Brief descriptions of each of the Phase I initiatives are contained in the next three subsections. Effectiveness in reducing ground-level ozone, a recommended schedule and mechanisms for implementing the Plan, jurisdictions responsible and costs are dealt with in subsequent sections.

VI.3 Description of NO_x Control Initiatives

a) National

Energy Conservation and Product Control (N100 series)

Initiative N101

Electric utility emission reduction targets and action plans based on emission reduction potential from demand side management (DSM), waste heat recovery and energy use optimization, and the increased use of low NO_x *alternative energy sources to generate electricity, by 1992.*

In 1985, power generation accounted for 247.9 Kt (13%) of Canada's NO_x emissions. This is forecasted to grow by 42% to 351.7 Kt (17.6%) of Canada's NO_x emissions by 2005. NO_x emissions and emission growth vary widely from region to region across Canada. It is recognized, therefore, that the potential to reduce NO_x will vary from utility to utility. However, electric power utility DSM programs, waste heat recovery and optimization strategies, and low NO_x-emitting alternative energy purchase/generation policies and programs do offer important opportunities to reduce NO_x emissions in some areas of Canada.

Demand Side Management refers to techniques for influencing the pattern and quantity of electricity demand by utility customers, in order to produce desired changes in the load shapes of electrical utilities. Overall, there are six (6) load shape objectives. These include: peak clipping, valley filling, load shifting, strategic conservation, strategic load growth and flexible load shape. Emission reductions are achieved by reducing the electricity generated at fossil-fueled power plants or by shifting some or all of the NO_x emitting generation sources to lower NO_x sources (nuclear, hydro).

Electricity consumption in Canada is 27% by residential consumers, 24% by commercial consumers and 41% by industrial consumers (line losses account for the other 8%). DSM programs will encourage electricity consumers to utilize energy efficient products and systems:

- ° Energy conservation measures that can be taken in the residential sector include actions to reduce space heating demands through insulation and window upgrades, heating, air conditioning and ventilation system enhancements, actions to reduce hot water use through better technology and improved use habits, and initiatives to upgrade lighting to more energy efficient lighting technologies.

- ° In the commercial sector, energy efficiency improvements can be made through upgrading lighting, heating and cooling, and building envelope upgrades. As well, motors and other equipment can be replaced by more efficient technologies.

- ° Industrial sector energy efficiency improvements can be made through measures such as upgrade to high efficiency electric motors, switching to induction heating of metal, switching to infrared radiation heating for drying surface coatings and heating materials for processing, replacing fossil fuelled furnaces with electric induction furnaces, switching to microwave heating, and installation of systems to recover waste process heat such as heat pumps and mechanical vapour recompression (MVR) systems. Some of these "electrotechnologies" will increase electricity demand thereby decreasing emissions at industrial sites at the expense of increasing emissions from power plants. However, the significant energy efficiency gains achievable are such that in most cases both electricity demand and industry emissions would be reduced. Where some increase in electricity demand occurs, the emission source is switched from the industry to the power plant where emissions are concentrated and more readily controlled, or where non-fossil electricity generation may be available to supply the increased demand. Trade offs with higher thermal efficiency cogeneration are also expected to occur.

Waste heat recovery and optimization offer significant potential efficiency gains and emission reductions in both utility and utility customer facilities. Heat pumps, heat exchangers, condensing heat recovery, cogeneration and thermal storage are some of the techniques for recovering waste heat and maximizing the use of energy after the initial combustion process.

Cogeneration is the simultaneous production of steam and useful electricity from a single fuel source. It is a reliable, efficient and environmentally sound supplement to utility-generated power. There are two types of cogeneration. In the one instance, exhaust steam from thermal electric generation can be used for a variety of process or space heat functions, including district heating systems. In the other instance, steam from industrial processes can also be utilized for electrical generation. In either situation, overall efficiencies can be increased from between 30 and 40% to approximately 80%.

Additional economic opportunities for low NO_x-emitting electrical supply may also exist for utilities in the use of alternative energy supply technologies such as biomass conversion, solar application, small hydro and wind energy systems.

It is estimated that a combination of strong utility DSM programs and energy efficiency performance standards (Initiative N102) should be able to reduce electrical energy demand nationally in 2005 by 20% of forecast levels. The NOx emission reduction estimates for Initiatives N101 and N102 combined are based on 15% of 2005 emissions for all utilities, leaving room for uncertainties and different stages of current utility DSM programs.

On average, about two thirds of this reduction is likely to be achieved through energy efficiency standards and one third through DSM, cogeneration and low NO_x energy purchases. The latter will vary from province to province, depending on generation mix and other factors, but overall the reduction estimates are considered to be conservative.

Recommendation:

° DSM emission targets and action plans be developed under coordination of Energy, Mines and Resources Canada in cooperation with provincial energy departments, utilities and other stakeholders, and include the effectiveness of energy efficiency performance standards under Initiative N102.

- ° The emission reduction goals be accomplished by the formal submission of action plans by all provincial electric power utilities to provincial energy departments before December 31, 1992, followed by annual reporting on program status and achievements.

Initiative N102

National energy efficiency performance standards for selected electrical equipment, appliances, motors, lighting systems, window systems and electrically heated buildings, effective in 1994.

Energy efficiency performance standards will ensure that new or replacement electric motors, appliances, windows, lighting and new buildings in Canada meet a minimum level of energy efficiency. They improve the potential for effectiveness of utility DSM programs aimed at encouraging electricity consumers to upgrade to more energy efficient facilities and equipment (Initiative N101). They would be an integral part of overall utility implementation plans based on DSM, cogeneration and other fossil-energy demand reduction opportunities.

The emission reduction estimates for Initiative N102 are combined with N101 reductions. The assumptions used are discussed under Initiative N101.

Target dates for energy performance standards under the plan are as follows:

	Equipment	Target Date
1.	White Goods (clothes washers, clothes dryers dishwashers, freezers, refrigerators, ranges) ° *it is assumed that Ontario Level Standards are adopted nationally by 1991*	1994
2.	Heating and Cooling Equipment (including dhw)	1994
3.	Lighting Equipment and Systems	1994
4.	Motors and Drives	1994
5.	Windows	1994
6.	Electrically heated buildings	1994

Recommendation:

- ° Energy, Mines and Resources Canada coordinate development of the energy efficiency performance standards identified above, in cooperation with provincial energy departments, utilities, manufacturers and builders, and other stakeholders.

- ° All standards and/or guidance documents be legislated by the appropriate federal, provincial, or municipal authorities to be effective no later than December 31, 1994.

Initiative N103

Energy efficiency performance standards and design guidance documents, and energy efficiency reporting in permit applications, for selected industrial sectors as specified in Schedule A.

Energy efficiency performance standards will define target levels for the energy efficiency of various industrial processes and energy efficiency design guidance documents will increase awareness among both designers and regulators of opportunities to minimize energy consumption by industry. Both the performance standards and the guidance documents will provide readily available criteria against which environmental impact statements and construction and operating permits for new industrial plants can be evaluated. Formally requiring that industry define in permit applications the energy efficiency measures taken and how they conform with the performance standards and guidance documents is expected to stimulate industry attention to energy efficient plant design and operating practices.

Target dates for energy efficiency performance standards and design guidance documents under the plan are listed in Schedule A below.

Schedule A

	Industry	Target Date
1	Iron & Steel Mills	31 December, 1992
2	Plastic & Synthetic Resin Manufacture	"
3	Industrial Chemical Plants	"
4	Cement Manufacture	"
5	Concrete Products Manufacture	"
6	Pulp & Paper Mills	31 December, 1993
7	Petroleum Refineries	"
8	Motor Vehicle Manufacture	"
9	Motor Vehicle Parts Manufacture	"
10	Other Petroleum & Coal Products Manufacture	"
11	Other Chemical Manufacture	31 December, 1994
12	Metal Stamping and Pressing	"
13	Tire & Tube Manufacture	"
14	Synthetic Textile Mills	"
15	Vegetable Oil Mills	"
16	Stone Products Manufacture	31 December, 1995

Schedule A was developed with consideration of industry sector energy consumption, NO_x and VOC emissions, SO_2 and CO_2 emissions, general proximity of the industry or electrical energy source to ozone problem areas, and anticipated growth of the sector. A primary information source for developing Schedule A was the Ontario detailed emission inventory. Revisions to this inventory may require adjustments in the target industries and target dates in the schedule.

Recommendation:

- ° Development of the energy efficiency performance standards and guidance documents be coordinated by Energy, Mines and Resources Canada in cooperation with provincial energy departments, industry and other stakeholders. The performance standards and guidance documents should be issued concurrently.

- ° Provincial departments require industry to describe, in Environmental Impact Statements and permit applications starting in 1992, energy efficiency measures they plan to incorporate in plant designs and plant operation, linking these to the performance standards and guidance documents as they become available.

Initiative N104

- Voluntary internal energy audits by industry in parallel with environmental audits by 1992.

Energy audits by industry to evaluate their performance against environmental standards and accepted good operating practices are an effective tool in promoting industry awareness within an industry itself of environmental shortcomings and opportunities for energy efficiency. As well additional opportunities may present themselves for cogeneration and waste heat utilization.

Recommendation:

- ° All industrial sectors establish formal energy audit procedures within their companies that link energy efficiency and environmental performance.

Initiative N105

New energy efficiency performance standards for fossil fuel heated buildings effective in 1994.

There is real potential for energy efficiency improvements in new buildings. This requires updating of provincial and municipal building codes, preferrably in a consistent manner across the country.

Recommendation:

- ° A systematic update of the "Measures for Energy Conservation" component of the national building code requirements for residential, commercial, institutional and industrial buildings be coordinated by Energy, Mines and Resources Canada, with a target date for completion of December 31, 1993. This should be done in cooperation with federal and provincial housing and energy authorities, such that the revised requirements can be incorporated into provincial and municipal codes.

Consumer Choice and Lifestyle (N200 Series)

Initiative N201

Public education campaign to encourage energy conserving driving habits and alternative transportation modes.

This campaign should concentrate on the summer ozone season, explaining the concerns with ground-level ozone and the contribution of automobiles to the ozone problem. There are many messages that could be delivered; these include the harm caused by higher emissions when driving above the speed limit, opportunities for trip consolidation and reduced emissions that would result, the need to minimize automobile use during peak ozone episodes and the environmental advantages of public transit.

Recommendation:

- The public education program be developed by the CCME NO_x/VOC Consultation Office in consultation with stakeholders. Educational materials would be produced and marketed on an annual bases beginning in 1991.

Initiative N202

Public education campaign to encourage voluntary energy conserving habits, product choices and design innovations in homes and businesses.

There are many topics that could be dealt with in this campaign. Examples include promoting purchase of energy conserving lighting equipment and appliances, promoting heating equipment and insulation upgrading, and presenting examples of energy conserving practices and habits in homes and business. All messages should be linked not just to energy conservation per se but to the environmental advantages of conserving energy.

Recommendation:

- The public education program be developed by the CCME NO_x/VOC Consultation Office, in consultation with stakeholders. Educational materials would be produced and marketed on an annual bases beginning in 1991.

Source Control Initiatives (N300 Series)

Initiative N301

New light duty vehicle (LDV) and light duty truck (LDT) NO_x emission standards, fully implemented no later than 1996, of:

For LDVs	0.4 g/mi
For LDTs	0.4 or 1.0 g/mi, depending on weight range

A light duty vehicle (LDV) is a gasoline or diesel fuelled vehicle designed for the transportation of people and having a designated seating capacity of not more than 12 people. A light duty truck (LDT) is a gasoline or diesel fuelled vehicle with a rated gross weight up to 8500 lb and that is designed primarily for the transportation of property or for the transportation of people, but having a designated capacity of more than 12 people, or that is available with special features that enable it to be operated off-street and off-highway.

NO_x emissions nationally from LDV/LDT were estimated at 453.1 KT (24% of total) in 1985 and are forecast to decrease to 238.2 KT (12% of total) by 2005.

The current NO_x emission standard for LDVs of 1.0 g/mi, which became effective in 1987, and for LDTs of 1.2/1.7 g/mi, which became effective in 1988, will result in a reduction in combined LDV/LDT emissions to half their current rate by year 2000, after which a gradual increase in emissions will take place through to year 2005 and beyond. Despite the substantial reduction in NO_x emissions, LDV/LDTs will still be the single largest source of NO_x in urban centres in year 2005.

A 0.4 g/mi limit for LDVs and 0.4/1.0 g/mi limits for LDTs are currently being phased in in California, and according to the proposed U.S. Clean Air Act amendments will be phased in nationwide in the United States over the 1993-96 period. Some LDVs have been certified below the 0.4 g/mi limit. However, the combination of a 0.4 g/mi NOx and a 0.25 g/mi hydrocarbon standard is technology forcing. The concern is with ensuring continuing compliance by vehicles in use.

The emission standards in Initiative N301 are identified in "A Plan to Identify and Assess Emission Reduction Opportunities from Transportation, Industrial Engines and Motor Fuels," jointly issued by Transport Canada and Environment Canada in May, 1989. A decision to proceed with implementation of the passenger car component of the LDV standard was announced by CCME in April, 1990.

Estimated emission reductions in 2005 for Initiative N301 are based on introduction of the tighter standards for LDVs in 1994 and for LDTs in 1995. 1996 is assumed to be the latest probable effective date for new standards for both LDVs and LDTs.

Recommendation:

° The new Canadian standard of 0.4 g/mi be established for LDVs before December 31, 1991 and for LDTs by December 31, 1992, through amendment to the current regulation under the federal Motor Vehicle Safety Act administered by Transport Canada.

Initiative N302

New heavy duty vehicle (HDV) NO_x *emission standards of (i) 5 g/BHP-hr with voluntary compliance in 1991 and regulation effective in 1994; and (ii) 4 g/BHP-hr or lower when another major jurisdiction has imposed an equivalent or tighter standard.*

The current Canadian NO_x limit for HDVs is 6.0 g/BHP-hr. The motor Vehicle Manufacturers Association and Engine Manufacturers Association have announced their intention to voluntarily adopt the new U.S. 1991 heavy duty emission standards and associated regulatory procedures in Canada. Compliance with the voluntary commitment will be verified by Transport Canada using the certification documentation requirements of the Motor Vehicle Safety Act. The existing Canadian regulation will also prevent the entry of motor vehicle engines that exceed the 6.0 g/BHP-hr limit. These engines can be built and sold in the U.S. because of averaging, banking and trading of emission credits and non-conformance penalties provisions in the U.S. regulations.

If the current Motor Vehicle Safety Act regulation is ammended to lower the NO_x limit from 6.0 g/BHP-hr to 5.0 g/BHP-hr, a new particulate standard (equivalent to the proposed 1994 U.S. standard) would be set at the same time. The tighter particulate standard and hence the timing of the regulation amendment, is dependent on the availability of lower sulphur diesel fuel in Canada. A federal program is underway to limit the sulphur content of diesel fuel.

The base emission forecast (NO_x/VOC Emission Forecast 90-B) used in developing the plan takes into account the voluntary compliance with the 5 g/BHP-hr limit. Even with all new HDVs meeting 5 g/BHP-hr, NO_x emissions nationally from HDVs in 2005 are estimated at 260.8 KT (13% of total NO_x), only slightly below the 1985 level of 285.2 KT. In the LFV and WQC, they will represent 24% and 17% respectively of total NO_x emissions by 2005.

The emission reduction estimate for Initiative N302 is based on the assumption that a 4 g/BHP-hr would be in effect for the year 2000 model year and that 40% of the vehicles would be meeting that standard by 2005. This results in only a modest additional reduction by 2005. It would still leave HDV NO_x emissions second only to NO_x from off-road diesel nationally when all plan initiatives have been implemented. In both the LFV and WQC, HDVs would become the largest source sector for NO_x, contributing 26% and 20%, respectively, of all NO_x emissions.

Since Canada imports its HDV engines, both the date and the emission level for a standard tighter than 5 g/BHP-hr is dependent on the timing and control level of a tighter standard in another major jurisdiction competing in the diesel engine market (e.g., California, United States, Europe). The emission level and timing of a tighter Canadian standard will have to be re-examined, and adjusted if necessary, as soon as plans for a tighter standard in another major jurisdiction are known.

Recommendation:

° Transport Canada verify industry voluntary compliance with the 5.0 g/BHP-hr NO_x limit through examination of certification documentation, beginning in 1991, and establish the 5.0 g/BHP-hr limit in regulation under the Motor Vehicle Safety Act, effective in 1994 (dependent on the avalability of low sulphur diesel fuel).

° A date and level for a standard tighter than 5 g/BHP-hr be jointly set by Transport Canada and Environment Canada, when additional regulatory action in another major jurisdiction is known.

Initiative N303

NO_x emission standards for diesel engines used in construction when standards for this use category have been established by another major jurisdiction.

A standard of 6 g/BHP-hr effective in 1998 has been used in calculating emission reductions for this Initiative.

Off-road diesel engines (mobile and stationary) are projected to be the second largest source of NO_x emissions nationally in 2005 at 317.4 KT (16% of total) without implementing the Plan, and the largest source sector at 234.8 KT (18% of total) after implementing the Plan. Fortunately, a significant percentage of off-road diesel engine emissions are not located in urban population centres (e.g., engines used in forestry, mining, agriculture, etc.). An exception is diesel engines used in construction. A significant percentage of construction activity is located in or near urban centres, and specifically within identified ozone problem areas. The rapid population growth in the greater Vancouver area, and industrial growth in the Windsor-Quebec corridor have resulted in intensive construction activity. The Darlington nuclear station, for example, just downwind of Toronto and in an area of frequent high peak ozone episodes, is at present the largest single construction project in North America.

The authority to regulate off-road diesel engines is included in the proposed amendments to the U.S. Clean Air Act. It is likely that regulatory measures will follow in the not too distant future.

The California Air Resources Board has examined the feasibility of controlling NO_x emissions from off-road, heavy duty construction equipment (Energy and Environmental Analysis, Dec. 1988). They identified three possible levels of control:

Level I	10.0	g/BHP-hr HC + NO_x
Level II	1.07	g/BHP-hr HC
	5.7	g/BHP-hr NO_x
Level III	1.07	g/BHP-hr HC
	4.5	g/BHP-hr NO_x

The 6.0 g/BHP-hr level assumed in calculating NO_x emission reductions for Initiative N303 is roughly equivalent to the California Level II. It represents about a 40% NO_x reduction from uncontrolled emission levels for many models of engines, which emit NO_x in the 10 g/BHP-hr range at optimum performance and fuel economy. More recent information from Calfornia suggests that the on-road standard of 5 g/BHP-hr may be adopted for diesel engines used in both construction and agriculture as early as 1994. There is also speculation that a comparable regulation may be brought in nationwide in the U.S. by 1995. The current estimate of emission reductions in Canada in 2005 based on 6 g/BHP-hr in 1998 may therefore be conservative.

Recommendation:

- A NO_x emission limit for diesel engines used in construction (and perhaps agriculture) be set under federal statute (Motor Vehicle Safety Act or Canadian Environmental Protection Act, amended if necessary) before

December 31, 1995. The limit and date of application would depend on control measures of equal or greater stringency being in place in another major jurisdiction (California, United States, European countries competing in the diesel engine market, etc.).

Initiative N304

Cap on NO_x emissions from Canadian rail transport systems at 115 Kt/Yr effective 1992.

Current (1985) NO_x emissions from rail transport are estimated at 132.1 KT (7% of total) nationally, and are forecast to decrease to 113.0 KT (6% of total) by 2005.

The NO_x emissions projections now included in the reference emission forecast for the plan (NO_x/VOC Emission Forecast 90-B) are based upon Railway Association of Canada development of traffic and fuel efficiency history and forecasts. Factored into the assumptions used are diesel locomotive replacements at a rate of 40 locomotives per year ($80,000,000 capital cost) in 1995 and beyond, and the expectation that new engines will emit 10% less NO_x than those currently in use.

This latter assumption is a component of a projected 14% decrease in NO_x from locomotives between 1985 and 2005. Principally, railway "system" improvements in productivity have reduced fuel consumption and are expected to continue to reduce fuel consumption and hence emissions per tonne-mile. Combined with predicted railway traffic growth and operational changes, a 14% decrease in NO_x is forecast. This supersedes a 26% increase estimated previously by the CCME which assumed status quo operational practices and engine performance.

Given the current unavailability of better engine technology and the uncertain future timing of engine technology improvements that will reduce NO_x, the 14% emission reduction forecast represents a cost-effective current estimate of what can be achieved over the 1985 to 2005 time period.

It is anticipated that long term development programs undertaken by the locomotive engine manufacturers (U.S. based) will ultimately result in commercial production of improved new locomotives for the replacement programs of the railways. Adoption of recognized commercially available, high fuel efficiency/low NO_x new locomotives will be required as existing locomotives are progressively replaced by new units. The ongoing locomotive fleet replacement programs of the railways inevitably involve locomotives in all regions of Canada. The Lower Fraser Valley and Windsor-Quebec Corridor regions will benefit from flexible railway locomotive operating management strategies, which maximize utilization and hence minimize fuel consumption and emissions.

Monitoring the compliance of railway carriers and the locomotive manufacturing industry with the above initiatives would best be undertaken by federal authorities, given the national nature of the major railways and the very wide range of usage of the locomotive fleet.

Recommendation:

- Environment Canada, in consultation with Transport Canada, the railways and other interested stakeholders, establish reporting requirements for railway carriers and the locomotive manufacturing industry by December 31, 1991.

Initiative N305

Successively tighter new source performance standards for NO_x from power plants effective in 1995 and 2000.

The following control levels (expressed as ng of NO_2 per joule of heat input) have been used in calculating 2005 emission reductions and should be used as a starting point for negotiating final 1995 and 2000 limits in a multistakeholder consultative process:

	Effective 1995	Effective 2000
Coal	150 ng/J	100 ng/J
Oil	110 ng/J	90 ng/J
Gas	50 ng/J	40 ng/J

Without implementing tighter NO_x control, power generation will be the largest source sector (mobile or stationary) for NO_x nationally by 2005 at 351.7 KT (18% of total emissions). Power generation emissions will be well above the next largest source category (off-road diesel engines at 16%), despite the assumption that there will be no new fossil generating capacity in Ontario and Quebec.

Most of the new fossil-fuelled generating capacity between now and 2005 is expected to be in Alberta, Saskatchewan and the Atlantic provinces, with possibly some additional capacity in British Columbia. Also most of the new capacity is expected to be coal-fuelled with some support from combustion turbine (gas or oil-fired) generation.

Much of the projected growth will not likely be in areas of most concern with respect to ground-level ozone. However, the growth in emissions without tighter control would be over 40% nationally by 2005, and considerably higher than 40% in some of the provinces installing new capacity (eg. 86% in Alberta). It is prudent to take preventive action to slow the rate of growth in emissions and minimize air quality degradation to the extent that technology will allow.

The current national emission guideline limits for NO_x emissions from coal, oil and gas-fuelled utility boilers are 258, 129 and 86 ng/J (ng of NO_2 per joule of heat input), respectively. These limits were based on technologies available in the 1970s.

Information in the NO_x/VOC Control Technologies Work Group report suggests that levels of 150, 110 and 50 ng/J are now achievable on new boilers without resorting to expensive flue gas cleanup technology such as selective catalytic reduction (SCR). Less expensive combustion modification technologies such as flue gas recirculation and fuel re-burning appear to be able to achieve these levels. The levels of 100, 90 and 40 ng/J would probably require the application of SCR. In fact with SCR, much lower levels (in the range of 50, 30 and 10 ng/J) can be achieved. SCR is a proven technology, being extensively applied in Europe and Japan on a range of sulphur content fuels.

Initiative N305 calls for an interim limit in 1995 to allow some flexibility and accomodate the long lead times necessary for power station planning, approval and development. This approach is considered to be reasonable, providing significantly reduced emissions from 1995 onward and hopefully stimulating the more rapid development of higher efficiency low emission combustion technologies, such as Integrated Gasification Combined Cycle (IGCC), as perferred options to meet a tighter limit in 2000.

In negotiating the year 2000 limit, serious condideration should be given to a limit based on NO_x per unit of useful energy output, where useful energy output includes heat as well as electrical energy. This would encourage cogeneration systems and higher efficiency electrical generation systems. It may also be the preferred form of control for CO_2 emissions under a greenhouse gas management program. A target level of 200 ng/J of useful energy output for all fuels, or variable levels of 200, 150 and 100 ng/J of useful energy output for coal, oil and gas fuelled systems, respectively, would be a suitable starting point for negotiating a year 2000 limit. NO_x and CO_2 limits could be determined in a common forum.

Recommendation:

- Environment Canada coordinate the guideline amendment process involving provinces, industry and other stakeholders, with a target date for completion of June 30, 1991 for the 1995 limit and December 31, 1994 for the 2000 limit.
- The negotiated limits for 1995 and 2005 be established by modifying the current thermal power emission guidelines under the Canadian Environmental Protection Act.
- The guideline limits, or more stringent control if chosen by the provinces, be implemented through provincial regulatory and/or permiting processes.

Initiative N306

New source performance standards, effective in 1994, for commercial/ industrial boilers and heaters.

The following control levels for NO_x (as NO_2) from commercial/industrial boilers and heaters have been used in calculating 2005 emission reductions and should be used as a starting point for negotiating final 1994 limits in a multi-stakeholder consultative process:

Coal	150 ng/J of heat input
Heavy Oil	110 ng/J of heat input
Light Oil	50 ng/J of heat input
Gas	30 ng/J of heat input

NO_x emissions nationally in 1985 from commercial/industrial boilers were estimated at 145.2 KT (8% of total). They are projected to grow substantially (by about 40%) by year 2005 to 207.3 KT (10% of total). The major difference between commercial/industrial boilers and utility boilers is that a higher percentage of the growth will occur in areas where ground-level ozone problems are most severe.

Initiative N306 calls for national new source performance standards for 1994 that are similar to the 1995 limits for power plants. The exceptions would be the addition of a limit to cover the smaller commercial/industrial boilers that burn light fuel oil, and possibly a lower limit for natural gas-fuelled boilers, which appears to be achievable on the gas-fuelled packaged boiler systems. Process heaters, which are included in this Initiative, may require a different set of limits. Emission limits for other fuels than those listed, particularly wood and refuse derived fuel, should also be considered in the standard setting process.

Initiative N306 does not call for tighter limits in year 2000, mainly because of the greater variability in boiler types and sizes in the commercial/industrial boiler population, and the relatively small percentage that are fuelled with coal. The need for a tighter limit could be re-examined when the Plan is updated in 1994.

Although emission reduction estimates have not included NO_x control for cement kilns, it is recommended that these also be considered in the standard setting process for this Initiative. They are a significant NO_x source and tend to have a higher percentage of their annual emissions during summer.

The technologies available to control NO_x emissions from commercial/industrial boilers and process heaters are similar to those for the larger utility boilers.

Recommendation:

- Environment Canada coordinate the development of a CCME national guideline defining the final NO_x emission limits for boilers and heaters (and possibly cement kilns) for 1994. The guideline would be established through a consultative process involving the various stakeholders and have a target date for completion of December 31, 1991.
- Provinces implement the CCME guideline through provincial regulatory and permitting processes.

Initiative N307

New source performance standards, effective in 1994, for NO_x from stationary combustion turbines.

An emission rate of 50 ng/J (33 ppmv) has been assumed in estimating NO_x emission reductions for new combustion turbines.

It is estimated that, including turbines used in the natural gas industry itself, gas and oil-fired combustion turbines emit about 15 Kt of NO_x annually, which is about 10 % of the NO_x emitted from commercial/industrial boilers and only 1% of national NO_x emissions. However, their use will continue to grow. Large combustion turbines are looked upon as an option to help meet future electricity demands. It is important to establish emission limits in the near future, before significant numbers of new turbines come into service.

The current U.S. EPA limits for gas-fired turbines are 150 ppmv for pipeline applications and 75 ppmv for utility applications. These regulations are quite dated (1979). The Northeast States for Coordinated Air Use Management (NESCAUM) has adopted maximum NO_x emission limits of 25 ppmv for gas-fired units and 42 ppmv for oil-fired units based on the conclusion that manufacturers will guarantee these emission rates (NESCAUM, 1988). NESCAUM also requires that selective catalytic reduction or other advanced technology(s) be shown to be inappropriate. If not, the NO_x limit for both gas-fired and oil-fired units is 9 ppmv. The NESCAUM limits are comparable to those of the California South Coast Air Quality Management District.

Recommendation:

° Environment Canada coordinate the development of a CCME national guideline defining the 1991 emission limits for new stationary combustion turbines. The guideline would be established through a consultative process involving all stakeholders and have a target date for completion of June 30, 1992.

° The CCME guideline be implemented by provinces through provincial regulatory and permitting processes.

Initiative N308

National adoption of the current Alberta NO_x emission standards for gas-fired reciprocating compressor engines, effective in 1993.

Gas-fired reciprocating compressor engine NO_x emissions in 1985 were estimated at 143 KT (8% of total) and are forecast to grow to 185 KT (9% of total) by 2005. This is equivalent to combined NO_x emissions from all other forms of commercial/industrial fuel combustion. However, these emissions are almost entirely in the three most westerly provinces, with more than 80% in Alberta. There are some reciprocating compressor engines used for gas distribution in Manitoba, Ontario and Quebec, but total emissions are insignificant.

Alberta has recently established NO_x emission standards for new gas-fired compressor engines. It is estimated that by 2005 the new standards will have reduced compressor engine NO_x emissions in Alberta by about 8% from the forecasted 2005 uncontrolled emission level. With this modest reduction and a projected strong industrial growth rate, compressor engines will remain the largest stationary source sector for NO_x in Alberta in 2005, contributing about 32% of province-wide emissions. While compressor engines make lesser percentage contributions to NO_x emissions in British Columbia and Saskatchewan they are still significant, and are expected to grow by 30% or more in these provinces by 2005.

The Alberta compressor engine standard of 5 g/BHP-hr (~6 g/kw) is tailored after standards in place in the states of Texas and California . The California South Coast Air Quality Management District is about to pass a rule requiring all internal combustion engines greater than 50 HP to be electrified unless they are for special designated uses.

Recommendation:

° A joint review of the Alberta standards be undertaken by British Columbia, Alberta and Saskatchewan.

° Alberta coordinate preparation of a national CCME guideline incorporating the Alberta standards, or a modified version of those standards, with a date for completion of December 31, 1991.

b) Regional

Energy Conservation and Product Control (N400 Series)

Initiative N401

Urban Transportation management plans designed to reduce NO_x*/VOC emissions - all urban centres in Lower Fraser Valley and Windsor-Quebec Corridor with population greater than 200,000 by 1992 and greater than 100,000 by 1994.*

It is estimated that substantial NO_x and VOC emission reductions (and reductions in CO_2 emissions) can be achieved by improving the efficiency of people and goods movement within urban areas. Traffic management or restraint policies, high occupancy vehicle priority, increased transit usage, promotion of walking and bicycling, and other similar measures are important contributors to emissions reduction in the short and medium term. The emission levels and patterns in large towns and cities, as they grow in future, will be mainly a function of urban planning policy - in particular policies determining density, zoning and provision for public transit. It has been shown that the structure and density of a city to a large extent "locks-in" the level of automobile dependency, and consequently energy consumption and emissions from automobiles. Also, the potential of some alternative fuels to reduce NO_x/VOC emissions, particularly in urban areas, has been established. Canada has the capability to immediately expand the use of natural gas and propane in transportation. Alcohol fuels and eventually electric vehicles could make contributions to NO_x/VOC reductions, and their development and demonstration should be encouraged.

As each urban area has unique features, the development of strategies to reduce emissions must be at the urban region level. It must be the responsibility of provincial, regional and municipal governments.

Recommendation:

- The provincial governments of British Columbia, Ontario and Quebec coordinate the development of management plans to reduce emissions from transportation in their urban centres, provide example planning frameworks as a guide to municipal and regional governments, and provide necessary incentives to ensure the Plan's implementation. To be most effective the planning process should involve the public and business groups in each urban area. Target dates for completion of the management plans would be June 30, 1992 for urban centres with populations greater than 200,000, and June 30, 1994 for urban centres with populations between 100,000 and 200,000.

- The federal government assist with research and studies to develop and demonstrate technology and strategies to reduce emissions from transportation in urban areas.

- In the area of alternative fuels, the federal government work with provincial governments to develop opportunities for cleaner fuels to be used in urban areas in particular; with vehicle manufacturers to develop alternative fuel vehicles; and with the alternative fuels industry on market development strategies and the provision of fuel supply infrastructure.

Consumer Choice and Lifestyle (N500 Series)

Initiative N501

Ozone "episode management" programs in place in the LFV and WQC in all urban centres with population greater than 100,000 and in major NO_x/VOC emission source areas outside these urban centres, by 1993.

It is reasonable to assume that NO_x and VOC emissions reach a maximum on hot summer days, coinciding with conditions that are conducive to high ozone levels. Additional fossil-fuelled electrical generation capacity may be brought on line to meet increased electricity demand for air conditioning, giving rise to increased NO_x. NO_x emissions from some industrial sectors, such as cement plants, also tend to be highest in summer. Evaporative VOC emissions from automobiles are greatest in hot weather, as are evaporative emissions from other VOC sources such as pesticide application and other forms of solvent use. Biogenic or natural VOC emissions are also at their maximum under these conditions, adding to the total ambient air concentrations of VOCs.

Certain activities could be reduced on the days for which an ozone episode is forecast. The actions to be taken can be grouped in three categories depending on the potential severity of the forecasted episode.

Actions taken during Category I episodes can be mostly voluntary. They aim at preventing ozone concentrations from reaching high levels which could be harmful to the public in the short term. Examples include notification of the public through the mass media to request its participation in abatement action, the banning of pesticide application and other organic solvent uses, and the provision of free bus rides.

Category II and III measures would be specific mandatory actions applied in addition to Category I measures, such as staggered or noon time start of work day, desincentives for private vehicles in downtown areas, prohibition of single occupant vehicles from entering the freeway system, periodic power interruptions to residential areas and industrial customers, and shutdown of major industrial emitters.

Recommendation:

° The provinces of Quebec, Ontario and British Columbia develop, in co-operation with the impacted industries and cities, ozone precursor curtailment plans for application during forecasted ozone episodes, by March 31, 1993. These plans would include a series of voluntary and mandatory measures to be applied, the conditions which would trigger the implementation of the plan (or parts of it), and estimates of the emission reductions likely to be achieved.

Initiative N502

More effective speed limit enforcement to reduce the average speed of heavy duty vehicles on major highways in summer by 1993 - LFV, WQC.

As noted in Initiative N302, heavy duty vehicles (HDVs) will remain the largest single source of NO_x emissions in the LFV and WQC in 2005, after the Plan has been put into effect. It is important that all opportunities to reduce emissions from this source sector be pursued.

Engine test data suggests that the amount of NO_x emitted by HDVs per km travelled increases rapidly as speed increases above the design speed. It is also well known that many of these vehicles routinely exceed the speed limits on highways. On multilane highways where speed limits are typically 100 km/hr, vehicle speeds, except in heavily congested areas, are commonly in the 110-120 km/hr range. For HDVs, this is likely to be above the speed that would produce minimum NO_x. However, better information on HDV NO_x emissions versus speed is needed to confirm this. Initiative N502 is included in the Plan subject to such confirmation.

More vigorous enforcement of speed limits would lead to a reduction in NO_x emissions from HDVs. This would be particularly important during warm summer months when ozone episodes occur. A more aggressive speed limit enforcement program would apply to all vehicles on major highways, even though most of the NO_x reduction potential is likely from HDVs.

The emission reduction estimates for Initiative N502 assume that a 10 km/hr reduction in average speed of HDVs on highways could be achieved and that this would lead to a 10% reduction of NO_x emissions from these vehicles. The 10% reduction has been applied to only 45% of HDVs, which is the approximate percentage of total HDVs travelling on major highways.

Because NO_x reductions from reduced average speeds would be achieved primarily by lower fuel consumption, this initiative would also reduce CO_2 emissions from this source sector by a similar percentage.

Recommendation:

- ° The provinces of British Columbia, Ontario and Quebec develop their own strategies, by December 31, 1992, for improved adherence with speed limits on major highways.

Initiative N503

Public education campaigns promoting the environmental benefits of reduced highway speeds in summer by 1993 - LFV and WQC.

This initiative is related to Initiative N502, and is aimed at increased awareness by truck owners and operators, police forces and the general public of the contribution of the heavy duty vehicle (HDV) sector to total NO_x emissions and ground-level ozone, and the opportunity to reduce that contribution by avoiding travel at excess speeds. It will be complementary to the speed enforcement program, and is aimed at reducing the costs of that program by achieving better voluntary compliance with existing speed limits on highways.

As with Initiative N502, implementation of this Initiative would depend on confirmation information on the variation of NO_x emissions with speed.

Recommendation:

- ° The provinces of British Columbia, Ontario and Quebec develop, by December 31, 1991, public education campaigns promoting the environmental benefits of reduced highway speed in summer.

Source Control Initiatives (N600 Series)

Initiative N601

Light duty vehicle (LDV) inspection and maintenance programs and anti-tampering legislation in the LFV and WQC by 1994.

Motor vehicle inspection and maintenance (I&M) programs usually consist of a regularly scheduled inspection of vehicles in a designated area to detect those vehicles emitting pollutants at rates greater than selected specifications or with inoperative or missing pollution control equipment. The owners of vehicles which fail an inspection are required to have them repaired before the vehicles can be relicenced. A compulsory inspection encourages owners not only to have their vehicles maintained in accord with a manufacturer's schedule but also to avoid tampering and misfuelling.

Compulsory inspection and maintenance programs for light duty vehicles have been in operation in certain areas of the USA since 1974. At present there are programs in over 50 urban areas in 31 states. Agencies considering the implementation of I&M in Canadian urban areas have a considerable data base of information to consult when researching possible program types for their area. The GVRD has already examined I&M program options and chosen a centralized contractor-operated program (GVRD 1989).

Motor vehicle I&M will reduce VOCs more than NO_x. It is estimated that I&M will reduce NO_x emissions by about 4% and VOC emissions by about 16%. These are conservative estimates, particularly for VOCs, where the 16% estimate is scaled down from higher California estimates to account for higher average annual tailpipe emissions (in relation to evaporative emissions) in the colder Canadian climate. Comparable VOC reductions (30% range) may be achieved in Canada in warm summer months when ozone episodes occur.

Tampering with emission control equipment is one of the causes of elevated emissions from motor vehicles. Comprehensive anti-tampering legislation with a policy on the use of aftermarket replacement parts, especially catalysts, would help aleviate this. Anti-tampering legislation enacted by the U.S. EPA requires that all cars have an original equipment catalyst for the first 5 years or 50,000 miles. Thereafter approved aftermarket catalysts can be used to replace a defective catalyst (NO_x/VOC Work Group on Control Technologies, 1990).

Recommendation:

- Motor vehicle I&M programs and anti-tampering legislation be developed and implemented in the LFV and WQC by British Columbia, Ontario and Quebec, with a target date for having these programs in place of December 31, 1993.

Initiative N602

Region specific new source performance standards for fossil-fuelled power plants in the LFV and WQC, to be effective by 1995, specifying NO_x emission limits no greater than 200 ng of NO_2 per joule of useful energy output on a plant basis.

AND

Region specific existing source performance standards for fossil-fuelled power plants in the LFV and the Ontario portion of the WQC, to be effective in 1997, specifying NO_x emission limits of either (i) the 1995 NSPS ng/J of energy output limits for these regions or (ii) a combined T/yr and summertime T/day plant emission cap that will result in no greater annual or summertime daily emissions than the 1995 NSPS level.

Without an aggressive retrofit program, fossil-fuelled power generation NO_x emissions in the WQC in 2005 will equal those from heavy duty vehicles (HDVs), with each of these sectors contributing about 18% of total NO_x in the corridor annually. While the HDV emissions are spread along the corridor, the power plant emission sources are for the most part at the upwind end (with respect to typical ozone episode weather patterns). In addition, the largest single power plant source of NO_x, the Nanticoke generating station, is located in the middle of the area having the greatest number of hours of exceedance of the maximum acceptable ozone objective in Canada; the Lakeview generating station is located within the Toronto urban area where other major sources of NO_x and large VOC sources occur; the Lambton generating station is at the absolute upward end of the corridor adjacent to large refinery and petrochemical industry VOC sources; and the Lennox generating station is in the middle of the ozone plumes from upwind Ontario and U.S. pollution sources. The Tracy oil-fired generating station just downwind of Montreal is also in the middle of a major urban plume, but represents only about 6% of the fossil-fuel generating capacity in the Ontario part of the corridor and is not a major concern. In the Lower Fraser Valley, the gas-fired Burrard generating station is located at the head of Burrard Inlet where peak ozone levels occur.

The most effective available NO_x control retrofit technology is selective catalytic reduction, which can achieve NO_x emission levels less than the NSPS levels specified in Initiative N602 even if the only useful energy output is electrical energy. Hence on multi-unit plants the ng/J plant limits specified in Initiative N602 might be met without having to retrofit all of the units with SCR or equivalent technology, thereby substantially reducing the overall cost of NO_x removal. In operation, preference could be given to use of the units equipped with high efficiency NO_x control, particularly during high ozone periods.

The advantages of a limit in the form of ng/J of energy output are discussed under Initiative N305. There are several other forms of NO_x control that could be used for existing power plants. These include:

- the traditional ng/J of heat input for each unit at a plant
- a ng/J of heat input limit on a plant basis
- a T/yr or T/day limit on all plants in a selected geographic region
- a T/yr or T/day limit for each plant
- shut down during ozone episodes

T/yr limits alone may do little to guarantee NO_x reductions when and where they are needed for ozone control unless the limit is sufficiently tight to force high efficiency control technology on all (or most) units at each plant. For example, a station like Lakeview (2400 MW) in Toronto may be able to stay within a fairly limiting annual cap with no add on NO_x control by operating at a fairly low capacity factor on an annual basis. However, without violating the annual cap all 8 units could be brought on line on a hot summer day to meet high electricity demand. When operating at full capacity, the Lakeview G.S. alone produces more than twice the daily NO_x emitted by all automobiles in the City of Toronto.

In the larger geographic region, the 4 operating power plants (10,400 MW) in the Ontario portion of the WQC, when operating at full capacity, can currently produce about 3 times the NO_x emissions from all automobiles in the Ontario portion of the corridor, and will have the capability to produce more than 4 times all automobile emissions by Year 2005 (with current automobile emission standards). An annual system cap, unless very stringent, could be met with control on one large station only (eg. Nanticoke) but still not prevent daily emissions from the system that are as much as 2 to 3 times all automobile emissions.

Hence, an annual NO_x cap alone, either for a plant or for a system is inappropriate for ozone control, which is of most concern on time scales of hours and days. However, it could be very effective for ozone control if combined with a T/day summer-time NO_x limit by plant or series of plants in a selected geographic region, and perhaps contingency shutdown plans for each plant during severe ozone episodes. For example, a 50 T/yr NO_x limit (as NO_2) for all plants in the Ontario portion of the WQC, combined with a summertime NO_x limit totalling no more than 100 T/day (as NO_2) for all plants (with appropriate geographic distribution of the 100 T/day), may afford more ozone protection than the ng/J plant limits specified in Initiative N602, while giving more flexibility in the choice of control.

Selection of the final form of NO_x controls for existing power plants is left to the provinces involved. In selecting the final form, there should be due regard to benefits other than just reduced summer ozone formation, such as winter NO_2 levels and winter nitrate deposition contribution to spring acid shock, etc. Any new plants in the LFV and WQC may also have to meet additional restrictions to the ng/J plant limits specified in the form of regional T/yr and T/day summertime caps.

Recommendation:

° The final provincial control programs be established by the governments of British Columbia, Ontario and Quebec, by December 31, 1992, both for new power plants commencing operation after December 1, 1994, and for retrofit of existing power plants by December 31, 1997.

Initiative N603

Retrofit 50% of existing commercial/industrial boilers and heaters in the LFV and WQC to the NO_x emission levels of the 1994 new source performance standard, by 1997.

The control levels used to estimate emission reductions for this Initiative are the same as those used to estimate emission reductions for Initative N306.

National new source performance standards for commercial/industrial boilers will bring about significant NO_x emission reductions from this category, due to the lower emissions from the new (or modified) boilers and process heaters (Initiative N306), and the penetration of new boilers into the existing boiler population. However, in ozone problem areas, further emission reductions from this sector should be obtained by retrofitting at least the larger existing commercial/ industrial boilers and process heaters, as these will continue to represent a major NO_x source (>10% of total NO_x in the WQC, >15% in the LFV), often in close proximity to other significant NO_x sources and major VOC source areas.

The retrofit program in Initiative N603 will focus on the larger, newer boilers and heaters which are not likely to be retired in the next 10-15 years, but currently have little or no NO_x control. The implementing jurisdictions may wish to extend the program to include cement kilns, as discussed under Initiative N306. This would require prior consultation with the cement manufacturing industry, as this sector was not involved in the consultation process for developing the Plan.

Recommendation:

° The provinces of B.C., Ontario and Quebec identify the candidate retrofit boilers, heaters and possibly cement kilns and establish, by December 31, 1993, retrofit limits (at or below the national new source performance standards), retrofit plans and retrofit schedules to ensure effective NO_x reductions from existing facilities by 1997.

Initiative N604

New source performance standards effective in 1995 and a retrofit program for completion by 1997, for NO_x process emissions from iron and steel mills in the WQC.

NO_x emissions from iron and steel processes in the WQC in 1985 were estimated at 4.0 KT (0.7% of total), and are forecast at 6.5 KT (1.1% of total) in 2005.

Iron and steel mills in Ontario are for the most part located in the heart of the WQC where ozone problems are most severe. NO_x emissions from fuel combustion at iron and steel mills are dealt with by the industrial boiler emission control initiatives (N306 and N603). Initiative N604 deals only with emissions deriving from iron and steel mill processes.

Sintering and coking are the primary sources of process NO_x emissions at iron and steel mills. Smaller process sources include blast furnaces, rolling mills and fluonitric pickling operations.

NO_x emissions can be controlled by fuel combustion improvements and installation of flue gas emission control equipment (such as selective catalytic reduction).

The emission reduction estimates for Initiative N604 are based on a 50% reduction from projected 2005 iron and steel mill process emissions. The highest efficiency control technologies could achieve greater reductions if applied to all processes within mills. However, there may be limitations on the applicability of technologies or the merits of selecting lower cost control for some processes. More information on NO_x emission sources and technology applicability will be needed to establish the final retrofit requirements.

Recommendation:

° Appropriate new source and retrofit emission limits for iron and steel process emissions be established by Ontario by December 31, 1993, for full implementation by December 31, 1997. The new source standards should also apply to plant modifications or process changes being made at existing mills. The retrofit program would apply to existing plant components that are not being replaced or modified as part of a plant upgrade.

Initiative N605

Retrofit refineries in the LFV and WQC to control NO_x process emissions, by 1997.

NO_x emissions from refinery processes were forecast at 1.9 and 15.4 KT (2.0 and 2.7% of total), respectively, in the LFV and WQC in 1985. They are forecast at 2.1 and 12.3 KT (3.1 and 3.2% of total), respectively, in 2005.

Refineries in both the LFV and the WQC are in the heart of the ozone problem areas. (The refinery in Saint John is also in an area that experiences elevated ozone levels and consideration might be given to retrofitting there as well). As with iron and steel mills, refinery combustion emissions are dealt with under the boiler emission control initiatives (N304 and N605). Initiative N605 deals only with refinery process emissions, which are estimated to contribute somewhere between 20 and 50% of total NO_x emitted by refineries, depending on which emission inventory source is used.

Catalytic cracking units in refineries are the primary non-combustion source of NO_x. High efficiency NO_x removal technologies such as selective catalytic reduction (SCR) could be applied to these units. The emission reduction estimates for this initiative are based on a 50% reduction from projected refinery process emissions in 2005. More information on the emission sources and technology applicability will be needed to establish the final refinery process retrofit requirements.

Recommendation:

- British Columbia, Ontario and Quebec work jointly to develop CCME guidelines, by December 31,1993, establishing common new source and retrofit standards and criteria, that could also be used in other jurisdictions.
- Each jurisdiction set its own retrofit implementation schedule and reporting requirements.

VI.4 Description of VOC Control Initiatives

(a) National

Energy Conservation and Product Control (V100 Series)

Initiative V101

Program to reduce VOC emissions from consumer surface coating application by 20% by 1997.

Emissions resulting from the presence of solvents in surface coatings (e.g., paints, enamels, varnishes, lacquers, etc.) represent 187.5 kilotonnes (10.5% of total VOC emissions) in the 1985 inventory. They are expected to grow to 253.6 kilotonnes (13.4% of total) in 2005. It is estimated that at least 30% of these emissions occur from coating applications which do not lend themselves to add-on controls: architectural coatings and consumer-applied coatings.

These emissions are closely related to population, i.e., most emissions occur in urban areas, most probably between May and September. These two reasons justify the importance of controlling consumer coating emissions.

Data from California suggest that some categories of paints can have their solvent content reduced by 60% or more by reformulation to low solvent or water base products thereby reducing emissions by the same percentage. Other types of coatings might be more difficult to reformulate.

A proposed amendment to the U.S. Clean Air Act requires the U.S. EPA to study the opportunities to reduce VOC emissions from consumer products, including coatings. This three year study is likely to be launched in the fall of 1990. A preliminary reduction target of 1% of total anthropogenic VOC emissions has been proposed at the outset of this study. Initiative V101 is consistent with the proposed U.S. target. The Canadian target of 20% will be reassessed in Phase II of the Plan, in light of the results of the U.S. study to incorporate additional reduction opportunities that are identified.

Recommendation:

° Environment Canada coordinate a task force composed of representatives from provincial governments, the coating manufacturers and any other stakeholders to prepare an emission reduction plan, by December 31, 1993. This reduction plan would be in two parts. It would first identify the measures to be taken and a schedule that would ensure a 20% minimum reduction is attained. The measures may include voluntary reductions, regulations, economic incentives or other means of achieving reductions as deemed necessary. The second part of the reduction plan would target, if possible, further emission reductions on a longer time frame for inclusion in Phase II of the Plan.

Initiative V102

Program to reduce VOC emissions from the use of adhesives and sealants by 40% by 1997.

Emissions from adhesives and sealants have been estimated at 35 kilotonnes in the 1985 inventory (2% of total emissions). Although the Adhesives and Sealants Manufacturers Association of Canada (ASMAC) has a different emission estimate, it has indicated that solvent use in adhesives and sealants and hence emissions, has decreased by an average of 4% per year between 1985 and 1990 (ASMAC 1990). ASMAC believes this trend will continue in future years for a variety of reasons. This should result in a 40% reduction of 1985 emissions by 1997 as targetted in Initiative V102.

Initiative V102 involves development of those measures needed to ensure that this downward trend in emissions does continue in the years to come. Issues that need to be addressed are the need for comparable controls for imported products, and the extent to which industrial or commercial uses of adhesives lend themselves to add-on controls.

Recommendation:

° Environment Canada coordinate a task force composed of representatives of all stakeholders to (i) review these issues and, by December 31, 1992, identify the products, if any, which will require the development of emission standards, and (ii) prepare a CCME guideline defining emission limits for these products, by December 31, 1993. The guideline limits should be readily convertible into product standards by an appropriate standard setting body or to VOC emission regulations under the Canadian Environmental Protection Act. The task force may also recommend other measures, such as economic incentives, that could replace regulations.

Initiative V103

Program to reduce VOC emissions from consumer products (excluding windshield washer and coatings) by 20% by 1997.

Emissions from consumer products, excluding windshield washer and coatings, were estimated at about 45 kilotonnes (2.5% of total emissions) in the 1985 inventory. The consumer product category probably includes thousands of products which are used for car care and maintenance, household cleaning and personal care. It is believed that one to two hundred product subcategories contain solvents which are potentially emitted to the atmosphere. Furthermore, it is expected that a thorough analysis of all these product subcategories will substantially reduce the number of them to be addressed under this initiative.

Pharmaceutical products, fragrances and flavours are excluded from any changes, at least in the near future, due to the apparent difficulty of reformulating these products. If future findings indicate that they are a significant source of VOCs and that some reductions are possible they could be targetted for long term reduction.

A proposed amendment to the U.S. Clean Air Act requires the U.S. EPA to launch a 3 year study aiming at identifying opportunities for emissions reduction from consumer products. This study is likely to be launched in the fall of 1990. A 1% reduction from total anthropogenic VOC emissions has been identified as a target at the outset. The 20% reduction of consumer product emissions proposed in this initiative is consistent with the U.S. EPA preliminary target.

The Canadian reduction plan would be in two parts. The first part would identify the measures to be taken and the schedule that would ensure a 20% minimum reduction is attained. The reduction plan may include regulatory measures, voluntary measures, economic incentives or other measures as deemed necessary. The second part would target further emissions reductions, if possible, on a longer time frame for inclusion in Phase II of the Plan.

Considerations in developing the plan, when product reformulation or replacement is recommended, would include:

- quality and efficiency of the new product.
- potential for creating new environmental or health hazards.
- impact of new product on other current environmental issues such as global warming, stratospheric ozone depletion, water pollution, waste generation, etc...

Recommendation:

° A CCME task force be formed under Environment Canada coordination in to monitor the progress of the U.S. study and to translate its results to a Canadian emission reduction plan by June 30, 1994. The task force would involve the participation of representatives from all interested stakeholder groups.

Initiative V104

Multi-element program to reduce VOC emissions from miscellaneous commercial and industrial solvent use by 20% by the year 2000.

Emissions from solvents used in miscellaneous commercial and industrial applications are estimated at 135 kilotonnes (7.5%) in the 1985 inventory. These emissions have a great number of sources: oilfield chemical use, vegetable oil extraction, paint stripping, rubber production, pharmaceutical and food processing, electronics manufacturing, petroleum refining, and many others. In these industrial or commercial settings, solvents are used as raw materials for product manufacture, as transfer agents or diluents, as wash-up material, as refrigerants or occur as by-products.

There is a potential for emission reductions either though product reformulation, more careful work practices or by the use of add-on controls.

This initiative involves the development of an emission reduction plan, after further investigative studies have been completed on solvent users and opportunities to control emissions and reformulate products

(Initiatives S304 and S305). The reduction plan would define the specific measures to be taken as well as the schedule and mechanisms for implementation. The proposed 20% emission reduction for the plan is considered only an interim target to be revisited and potentially tightened in Phase II of the Plan.

Recommendation:

° The reduction plan be developed under Environment Canada coordination with a target date for completion of December 31, 1994. The plan would be developed through a consultative process with solvent manufacturers, solvent users, provincial governments, environmental organizations and any other interested stakeholders.

Consumer Choice and Lifestyle (V200 Series)

Initiative V201

Public education campaign to encourage energy conserving driving habits and alternative transportation modes.

See description of Initiative N201.

Initiative V202

Public education campaign on solvents to (for example):

- *encourage use of water-base coatings,*
- *encourage the purchase of alternative consumer products which do not emit VOCs,*
- *encourage solvent recovery & recycle, and*
- *increase industry awareness of concerns and options.*

Identifying the environmental issues and potential solutions for consumers is a very important task since consumers are the cause of a significant amount of the VOC emissions from solvent use. A series of media information materials will be developed, each focussing on a particular topic area with which consumers can readily identify. Each will convey messages of environmental preservation and health protection (eg. ground-level ozone, indoor VOCs, etc.), and present actions that the consumer can take to reduce emissions.

Another way to inform consumers about options that are available to reduce the environmental impacts of their activities is by consumer product labelling programs such as the Canadian Environmental Choice Program. Activities undertaken under Initiative V202 would be consistent with, and supportive of, such programs.

Information transfer materials will also be developed to increase commercial/industrial user awareness of concerns and options available for such things as solvent recovery and recycle.

Recommendation:

- The public education program on solvents be coordinated through the NO_x/VOC consultation office, with production of public education materials annually throughout the 1991-1994 period.

Source Control Initiatives (V300 Series)

Initiative V301

New light duty vehicle (LDV) and light duty truck (LDT) VOC emission standards fully implemented no later than 1996, of:

For LDVs	*0.25 g/mi*
For LDTs	*0.25 or 0.32 g/mi, depending on weight class.*

A light duty vehicle (LDV) is a gasoline or diesel fuelled vehicle designed for the transportation of people and having a designated seating capacity of not more than 12 people. A light duty truck (LDT) is a gasoline or diesel fuelled vehicle with a rated gross weight up to 8500 lbs, and that is designed primarily for the transportation of property or for the transportation of people, but having a designed capacity of more than 12 people; or that is available with special features that enable it to be operated off-street or off-highway.

VOC emissions from LDVs and LDTs represent 31% (556.8 kilotonnes) of the total emissions in the 1985 inventory. They are, however, forecast to decrease (due to the gradual replacement of old vehicles with post 1987 vehicles) until the year 2000. The emission forecast indicates they will still represent 18.5% of total anthropogenic VOC emissions by the year 2005.

The current Canadian VOC standard for tailpipe emissions from LDVs and LDTs is 0.41 g/mi (adopted in 1987). Technology to reduce tailpipe emissions to 0.25 g/mi has been demonstrated and is readily available. This limit is expected to be adopted nationwide in the U.S. by 1994 for at least part of the vehicle fleet.

The emission standards in Initiative V301 are identified in "A Plan to Idendity and Assess Emission Reduction Opportunities from Transportation, Industrial Engines and Motor Fuels" jointly issued by Transport Canada and Environment Canada in May, 1989. A decision to proceed with implementation of the passenger car component of the LDV standard was announced by the CCME in April, 1990.

Estimated emission reductions in 2005 for Initiative V301 are based on introduction of the tighter standards for LDVs in 1994 and for LDTs in 1995. 1996 is assumed to be the latest probable effective date for new standards for both LDVs and LDTs.

Recommendation:

- The new Canadian standard of 0.25 g/mi be established for LDVs before December 31, 1991, and for LDTs by December 31, 1992, through amendment to the current regulation under the federal Motor Vehicle Safety Act administered by Transport Canada.

Initiative V302

New sources performance standard for tanks storing volatile organic liquids, effective in 1993.

The current forecast indicates that emissions from new storage tanks may account for 0.5% (10 kilotonnes) total VOC emissions in 2005.

This initiative requires that tanks storing volatile organic liquids be equipped with vapour control equipment having an emission reduction efficiency similar to the U.S. EPA standard for new tanks.

It is now common industrial practice to incorporate some form of vapour control on large storage tanks containing volatile liquids, partly because of the cost effectiveness of the measure. Some provinces already have some standards in place for this source (NO_x/VOC Work Group on Control Technologies 1990). The current initiative aims at extending this measure to tanks of a smaller size storing highly volatile material or tanks storing large quantities of liquids of moderate volatility, both of which can potentially be significant sources of emissions. It would establish minimum size and liquid volatility thresholds over which controls would apply; it would also take into account the significance of the emission reductions anticipated as well as the cost effectiveness of the measures contemplated. Exemptions for tanks located in remote areas could be considered.

The emission reductions for this initiative have been estimated using an average 90% reduction of projected emissions from storage tanks in the petroleum refining and organic chemical manufacturing sectors. The NSPS will, however, not be limited to these two sectors.

Recommendation:

- The NSPS be established in a CCME guideline to be developed under Environment Canada coordination, with a target date for completion of December 31, 1991. The guideline would be developed using a multi-stakeholder consultation process.

- The guideline be adopted by provincial jurisdictions or implemented through provincial permit systems.

Initiative V303

New source performance standard for process emissions from organic chemical plants, effective 1994.

The organic chemical industry is the second largest industrial source of VOCs. Emissions from organic chemical process units built after 1985 are forecast to represent 12 kilotonnes by 2005 (0.6% of total projected emissions).

There are about one hundred different processes used in Canada at the moment to manufacture the 60 most produced organic chemicals. These processes can, however, be grouped into process categories as the U.S. EPA has done to establish its NSPS.

Initiative V303 requires that process units at organic chemical plants, the construction of which will start after December 31, 1993, be equipped with control equipment reflecting the current or proposed U.S. EPA NSPS efficiency. The NSPS would also apply to the supplementary production from expanded facilities. Consideration should also be given to recycling/reuse of emissions when feasible.

While new organic chemical process units generally include emission control equipment when necessary, this measure aims at maximizing the emission reductions to be obtained from new plants or process units.

Emission reduction estimates have been calculated using an average 85% reduction of 2005 forecast emissions. Emissions forecasts take into account the current level of control in the organic chemical sector.

Recommendation:

- A CCME guideline be developed under Environment Canada coordination with a target date for completion of December 31, 1992. The guideline would be prepared through a multi-stakeholder consultation process.
- The guideline be adopted in provincial regulations or implemented in permit systems as required.

Initiative V304

Requirement that fugitive emission inventory and leak reduction programs be implemented at new organic chemical plants, effective 1993.

Fugitive emissions are leaks from equipments such as valves, flanges, pumps and compressors.

Emissions from the organic chemical sector are forecast to grow from 36.4 kilotonnes in 1985 to 51.3 kilotonnes (2.7% of total forecast emissions) in 2005. A recent survey (Edwards 1990) indicates that about 42% of these emissions are fugitive emissions. Although there is some controversy about the methods used to estimate fugitive emissions, they appear to represent a significant source of VOCs. The forecast also indicates that there will be a significant growth in organic chemical production in Canada. All these considerations justify the setting of limits for this particular source.

Initiative V304 requires that organic chemical plants, the construction of which will start after December 31, 1992, establish programs to better estimate their fugitive emissions and to reduce these leaks when they begin production. This measure also applies to supplementary production from expanded facilities. The Canadian Chemical Producers Association has already indicated its support of a similar initiative (CCPA 1990). The province of Alberta already requires a fugitive emission control program in its permits.

Emission reductions for this Initiative have been estimated using an average 56% reduction of the 2005 forecast emissions.

Recommendation:

- ° A CCME code of practice be developed for this measure under Environment Canada coordination, with a target date for completion of December 31, 1991. The code would be developed by a multi-stakeholder task force. It would cover fugitive emissions control for both new and existing organic chemical plants (Initiatives V304 and V609) and for petroleum refineries (Initiative V607), given the similarity of these source sectors.

- ° The code be implemented by provincial authorities through provincial regulatory or permit systems.

Initiative V305

New source performance standards for plastic processing plants, effective 1995.

Emissions from the plastics processing sector are forecast to grow from 13.6 kilotonnes in 1985 to 29.4 kilotonnes (1.6% of total forecast emissions) in 2005. Emissions from plants or process units built after 1985 would be about 20 kilotonnes.

This measure requires that plastic processing plants the construction of which will start after December 31, 1994, control their process emissions to the best available control technology economically achievable level. This would also apply to supplementary production from expanded facilities.

The plastic processing sector is a very diversified one, involving many types of processes, facilities, raw materials and products. The proposed standards would have to focus on the processes which emit the largest quantities of VOCs. The location of the sources could also influence the choice of processes to be covered.

There is some uncertainty regarding the current emission estimate and the control technologies or options available to this sector. Studies will be undertaken to fill these gaps (Initiatives S103 and S302).

Emission reductions for this initiative were estimated based on an assumed average 90% reduction efficiency applied to 50% of the forecast emissions from plants to be built in 1995 or after.

Recommendation:

- ° The specifics of this measure be established in a CCME guideline to be developed under Environment Canada coordination, with a target date for completion of June 30, 1993. The guideline would be developed through a multi-stakeholder process.

- ° The guideline be implemented by provinces using provincial regulatory or permit systems.

Initiative V306

New source performance standard for sulphate process in pulp and paper plants, effective 1994.

Emissions from this sector are forecast to grow from 14 kilotonnes in 1985 to 25 kilotonnes (1.3% of total forecast emissions) in 2005.

This measure requires that emissions from sulphate (kraft) processes in pulp and paper plants, the construction of which will start after December 31, 1993, be either reduced through process changes or captured and controlled with the best available control technology economically achievable for new sources. This measure also applies to supplementary production from expanded facilities.

There is some uncertainty regarding the current emission estimate and the control technologies or options available for this source. Studies will be undertaken to fill these gaps (Initiatives S103 and S302).

Emission reductions for this initiative have been estimated using an average 60% reduction efficiency applied to emissions from sulphate process units to be built in 1994 of after.

Recommendation:

- The specifics of this initiative be established in a CCME guideline under the coordination of Environment Canada with a target date for completion of December 31, 1992.
- The guideline be implemented through provincial regulatory or permit systems.

Initiative V307

New source performance standards for commercial/industrial coating application facilities, effective 1994.

Emissions from industrial and commercial coating application are estimated at 130 kilotonnes in the 1985 inventory. They are forecast to reach 176 kilotonnes (9.3% of total forecast emission) by 2005. Industrial coating application takes place at plants manufacturing automobiles, furniture, household appliances, farm machinery, building materials, fabrics and other simlar products. Commercial coating application takes place at facilities such as automobile paint shops and furniture repair shops.

Add-on emission control devices, involving mainly incineration or adsorption, can reduce VOC emissions by 90-99%, depending on the solvent type and content in the flue gas. However, some facilities might not be amenable to add-on controls at a reasonable cost. Coating reformulation is another option which might be available in some cases. Finally, for some facilities, modification of the application techniques and improvements to operating and maintenance practices can lead to substantial emission reductions. The Montreal Urban Community currently requires a 90% reduction of emissions from certain commercial and industrial surface coating operations in its jurisdiction (Communaute Urbaine de Montreal 1987).

Initiative V306 involves the identification of appropriate subcategories within the commercial/industrial coating application sector for evaluating control options, selecting emission control levels and setting emission standards for each subcategory. Data on these will be obtained through Initiative S304 and S305.

Emission reductions for this initiative have been estimated using an average 90% reduction at 90% of the industrial facilities and 60% of commercial facilities to be built in 1994 or after.

Recommendation:

- A CCME code of practice or guideline for this measure be developed under Environment Canada coordination, with a target date for completion of December 31, 1992.
- The guideline be implemented by provinces through provincial regulatory or permit systems.

Initiative V308

New source performance standards for commercial/industrial printing facilities, effective 1994.

Commercial and industrial printing emissions were estimated at 20 kilotonnes in the 1985 inventory. These emissions are forecast to reach about 22 kilotonnes (1.2% of total forecast emissions) in 2005. Although the growth in emissions is modest, it is estimated that approximately 50% of such facilities will be replaced or rebuilt between 1985 and 2005.

The available information indicates that there are two types of printing processes which have very little emission control at present. These are rotogravure printing and flexography printing, which together account for 80% of VOC emissions from the printing sector. Other types of printing are estimated to have about 60% of their VOC emissions controlled (NO_x/VOC Work Group on Control Technologies 1990).

Emission reduction options can be classified in three broad categories: process or equipment modification, ink reformulation (to water-base or low-solvent base) and add-on control equipment (carbon absorption, incineration, biological filtration, etc.). The overall emission control efficiency varies depending on the option(s) selected, the type of process in place and the nature of the inks used. The Montreal Urban Community has established a bylaw requiring a 90% reduction of VOC emissions from certain printing facilities in its jurisdiction. (Communaute Urbaine de Montreal 1987).

This initiative involves evaluation of control options available to printing facilities and establishment of recommended emission limits. The limits will be based on the results of studies to be conducted under Initiatives S304 and S305.

Emission reductions for this Initiative have been estimated using a 90% reduction of emissions from printing facilities built in 1994 or after.

Recommendation:

- A CCME environmental code of practice for this initiative be developed under Environment Canada coordination, with a target date for completion of June 30, 1993. The code development will involve appropriate stakeholder consultation.
- The code be implemented by provinces using provincial regulatory authorities and/or permit systems.

Initiative V309

New source performance standard for commercial/industrial degreasing facilities, effective 1995.

Solvent degreasing (or solvent cleaning) is the physical process of using, in most applications, an organic solvent to remove grease, fat, oils, wax or soil from various metal, glass or plastic items. Degreasing is done as a preparatory step to subsequent operations such as coating, plating repair, assembly and machining.

Commercial and industrial degreasing is estimated to account for 17.5 kilotonnes of the 1985 inventory. Emissions are expected to grow to 19.1 kilotonnes (1% of total forecast emissions) in 2005. About 50% of the facilities are expected to be replaced or rebuilt between 1985 and 2005.

Although the substitution of solvents with alkaline or low volatility offers the greatest potential for reducing VOC emissions from degreasing, add-on controls can achieve significant reductions at larger manufacturing facilities where centralized units can be employed. Degreasing equipment redesign or better operational procedures also offer some VOC reduction potential. The Montreal Urban Community has established a bylaw requiring a 90% reduction of VOC emissions from the degreasing of metal parts. (Communaute Urbaine de Montreal 1987).

Initiative V309 involves the further evaluation of available control technologies and practices and the establishment of emission limits for new degreasing facilities. Studies to assist in this task will be conducted under Initiatives S304 and S305.

Emission reductions for this initiative have been estimated using an average 80% reduction of emissions from commercial and industrial degreasing facilities built in 1995 or after.

Recommendation:

- ° A CCME environmental code of practice be developed for this initiative under Environment Canada coordination, with a target date for completion of June 30, 1994. The code would be developed through a consultative process with appropriate stakeholders.
- ° The code be implemented by provinces using provincial regulatory authority and/or permit systems.

Initiative V310

New source performance standard for dry cleaning facilities, effective 1995.

Dry cleaning involves the cleaning of fabrics with nonaqueous organic solvents. The two general solvent types used are petroleum solvents and synthetic solvents (perchlorethylene), with the latter accounting for 75% of total dry cleaning solvent use in Canada.

Emissions from dry cleaning operations are expected to grow from 14 kilotonnes in 1985 to 15.5 kilotonnes (0.8% of total forecast emissions) in 2005. About 50% of the existing facilities are expected to be replaced or rebuilt between 1985-2005.

The cleaning solvent itself is the primary VOC emission from dry cleaning operations. Solvent is given off during washing, drying and solvent recovery operations. The dry cleaning process could be altered or amended to achieve some VOC reduction primarily through enclosure of the whole dry cleaning sequence to minimize solvent losses. Better equipment maintenance and using good operating practices can have a significant impact on emissions. Add-on controls can also be effective in reducing VOC emissions. As with other operations, these add-on controls are more ideally used in larger facilities where centralized units can be installed. The Monteral Urban Community has established a bylaw requiring a 97% reduction of VOC emissions from dry cleaning facilities on its territory (Communaute Urbaine de Montreal 1987).

Emission reductions for this Initiative have been estimated using an average 80% reduction of 80% of the emissions from dry cleaning facilities built in 1994 or after.

Recommendation:

- ° Environment Canada coordinate development of a CCME environmental code of practice defining emission limits and outlining available control options, good operating practices and equipment maintenance requirements for dry cleaning facilities. A certification program for operators would be included as an important component of the control strategy. The code development would involve stakeholder consultation and be complete by December 31, 1993.

- Provincial governments implement the code through provincial regulatory and/or permit systems.

b) Regional

Energy Conservation and Product Control (V400 Series)

Initiative V401

Urban transportation management plans designed to reduce VOC emissions - all urban centres in Lower Fraser Valley and Windsor-Quebec Corridor with population greater than 200,000 by 1992 and greater then 100,000 by 1994. [Same as Initiative N401]

See description of Initiative N401.

Consumer Choice and Lifestyle (V500 Series)

Initiative V501

Ozone episode management programs in place in all urban centres with population greater than 100,000 by 1993 in the LFV and WQC. [Same as Initiative N501]

See description of Initiative N501.

Source Control Initiative (V600 Series)

Initiative V601

Light duty vehicle inspection and maintenance programs (I&M) and anti-tampering legislation in the LFV and WQC by 1993. [Same as Initiative N601]

See description of Initiative N601.

Initiative V602

Reduction in gasoline volatility in 1992 in the LFV, WQC, New Brunswick and Nova Scotia to:

62 kPa RVP (9.0 psi) for June, July & August
72 kPa RVP (10.5 psi) for May & September

Volatility is the propensity of liquids to evaporate. Volatility of gasoline is usually measured by a standard method called the Reid Vapour Pressure (RVP) method. Before 1989, gasoline volatility ranged from 79 kPa to 86 kPa during the summer time in the areas covered by Initiative V602. Other liquid fuels do not significantly contribute to VOC emissions.

The provinces of Ontario and Quebec imposed summertime volatility limits in 1989 and a 72 kPa volatility limit was implemented in all provinces during the summer of 1990. The Canadian Petroleum Product Institute supported and cooperated to this initiative (CPPI 1990). The U.S. is expected to promulgate regulations, soon after the proposed Clean Air Act Amendments are passed, to limit summertime volatility nationwide in the U.S. to 9.0 psi RVP (62 kPa).

Some stakeholders have argued that the same emission reductions could be more economically achieved by the use of control systems (larger carbon canisters) on-board motor vehicles. While this option is still being considered in the U.S., it is considered in conjunction with a reduction of gasoline volatility. Whether or not larger carbon canisters are adopted for north american cars, the anticipated reductions in vehicle evaporative emission (operating and refuelling) are based on reduced gasoline volatility. Another important consideration is that a reduction of gasoline volatility immediately translates into an emission reduction from all vehicles while on-board control when adopted will take ten to fifteen years to phase in because of the rate of replacement of the car fleet.

Volatility reduction is one of the most effective VOC reduction initiatives in the Plan, accounting for about 46 kilotonnes of VOCs in 2005, or 12% of all VOC reductions. These reductions are split between automobile hydrocarbon evaporative loss reductions (80%) and gasoline distribution system vapour loss reductions (20%).

Emission reductions for this Initiative were estimated using a 10% reduction of emissions from all gasoline distribution and marketing activities and through the MOBILE4C program for mobile sources emissions.

Recommendation:

- ° The 62 and 72 kPa volatility limits in Initiative V602 be implemented by the provinces involved. A slight shift in timing of application of the volatility limits in the Maritimes to June and September for 72 kPa, July and August for 62 kPa, is recommended. The cutoff date in September for all provinces could be September 15th, since serious ozone episodes beyond that date rarely occur.

Initiative V603

Requirement for vapour balancing and recovery at gasoline storage and transfer depots (bulk and marketing terminals):

- *New and expanded depots*
  - *Vapour balancing and recovery in the LFV and WQC, effective 1992*
  - *Provision for vapour balancing and recovery everywhere else in Canada, effective 1992*
- *Existing depots*
  - *Vapour balancing and recovery in the LFV and WQC by 1993.*

Emissions from gasoline storage and transfer depots in the LFV and WQC are forecast to grow from 16.6 kilotonnes in 1985 to 20.4 kilotonnes (2.1% of total forecast emissions in LFV and WQC) by 2005.

Initiatives V603 and V604 together form what is called Stage I control for gasoline vapours.

The provinces of British Columbia and Ontario have already identified their intention to proceed with Stage I control in ozone problem areas. The CCME endorsed the implementation of Stage I control in ozone problem areas at its October 1989 meeting. To ensure consistency in application in different regions, a CCME code is now being developed containing the specifics for vapour balancing and recovery systems, the performance standards expected and the certification programs needed.

The first part of this initiative (new and expanded depots) requires that any new depots (or the expanded portion of existing depots), the construction of which begins after December 31, 1991 be equipped with the necessary piping to allow the balancing of gasoline vapours. New depots should also include the necessary infrastructure to install a vapour recovery unit (VRU). The full implementation and operation of vapour balancing and recovery would, however, take place only in the WQC and LFV commencing May 1st, 1992. Other jurisdictions will be free to adopt vapour recovery when they judge it necessary.

The second part of Initiative V603 (existing depots) requires that existing depots be retrofitted for vapour balancing and recovery in the WQC and LFV by May 1st, 1993.

Although this retrofit applies only to the WQC and LFV at this time, it should be given serious consideration for urban areas in other regions. It is not only very cost effective, but would provide broader access to equipped terminals, and the opportunity for full implementation of Stage I controls as the number of new equipped service stations grows.

Emission reductions for this initiative were estimated using an average 86% reduction of related 2005 forecast emissions.

Recommendation:

° The CCME code of practice for Stage I controls currently being developed under Environment Canada coordination be finalized by December 31, 1990.

° The provisions in the code of practice be implemented by provinces using provincial legal authorities.

Initiative V604

Requirement for gasoline delivery vapour balancing at service stations.

- *New service stations*
    - *Vapour balancing in the LFV and WQC, effective 1992*
    - *Provision for vapour balancing everywhere else in Canada, effective 1992.*
- *Existing service stations*
    - *Vapour balancing in the LFV and WQC by 1993.*

Emissions from delivery at service stations in the LFV and WQC were estimated at 16.9 kilotonnes in the 1985 inventory. They are forecast to grow to 20.8 kilotonnes (2.2 % of total forecast emissions in the LFV and WQC) by 2005.

This initiative, combined with Initiative V603, forms what is called Stage I control for gasoline vapours. Provincial plans and CCME endorsement of Stage I control for ozone problem areas are identified under Initiative V603.

The first part of this measure (new service stations) requires that new service stations, the construction or revamping of which starts after December 31, 1991, be equipped with the appropriate equipment to allow the transfer of gasoline vapours from underground storage tanks to delivery trucks during gasoline deliveries. For the purpose of this measure, the replacement of underground storage tanks constitutes a revamping of a service station.

The full implementation and operation of vapour balancing would take place only in the WQC and LFV, starting on May 1, 1992. Other jurisdictions would adopt Stage I control if and when they judge it necessary.

The second part of this Initiative (existing service stations) requires that existing services stations in the WQC and LFV be retrofitted to allow for gasoline vapour balancing by May 1st, 1993. Although this retrofit only applies to the WQC and LFV, it should be given serious consideration for other urban areas. It is one of the most cost-effective VOC emission control measures when there is sufficient gasoline throughput.

Another important consideration is the tightness of the tank trucks which carry gasoline vapour from the sevice station to the storage depots. Truck tightness has to be insured.

Emission reductions for this initiative were estimated using an average 84% reduction of related 2005 forecast emissions.

Recommendation:

° The CCME code of practice for Stage I controls currently being developed under Environment Canada coordination be completed by December 31, 1990.

° The code be implemented by provincial jurisdictions using provincial legal authorities.

Initiative V605

Requirement for vehicle refuelling vapour balancing at service stations in the LFV and WQC:

- *New stations from May 1, 1993*
- *Existing stations by December 31, 1995*

Emissions from vehicle refuelling at service stations in the LFV and WQC are expected to grow from 23.5 kilotonnes in 1985 to 28.8 kilotonnes (3% of total forecast emissions in the LFV and WQC) in 2005.

This measure requires that new and existing service stations be equipped with the piping and fittings necessary to ensure the transfer of gasoline vapour from vehicle tanks to service station tanks during the refuelling of the vehicle. This measure, known as Stage II control, would apply to the LFV and WQC.

Although this is a costly measure, it addresses roughly 40% of the gasoline marketing network total emissions. The reductions expected represent 5.5% of total anticipated VOC reductions across Canada. Some economies can be realized on installation cost, since many underground storage tanks will be replaced in the next five years under a CCME program for management of underground storage tanks. Service station owners in the LFV and WQC should take advantage of this opportunity.

Some stakeholders have argued that the same emission reductions could be more economically achieved by the use of control systems (larger carbon canisters) on-board motor vehicles. There are two reasons why this option is not favoured at this time. First, the use of on-board controls is still being debated in the U.S. If the on-board control option is not adopted in the U.S. the costs to adopt it in Canada only would be greater than the costs associated with Stage II control. Second, a reduction through Stage II control will affect all vehicle refuelling in the WQC and LFV at the date it becomes effective while on-board control when adopted will take about ten more years to provide the same level of reduction because of the rate of replacement of the car fleet. The adoption of this measure will be reassessed with regard to the situation in the U.S. prior to the implementation date for new service stations (May 1993) and prior to the implementation date for existing service stations (1995) if need be.

Emission reductions for this initiative have been estimated using a reduction efficiency of 80% of related 2005 forecast emissions.

Recommendation:

- A CCME code of practice be developed under Environment Canada coordination, with a target date for completion of December 31, 1991. The code would ensure consistency of the type of equipment used across Canada.
- Provincial jurisdictions implement provisions of the code using provincial legal authorities.

Initiative V606

Retrofit of tanks storing volatile organic liquids in the LFV, WQC and SJA to BACTEA by 1994.

Emission from this source in the LFV, WQC and SJA were estimated at 15 kilotonnes in the 1985 inventory (1.7% of total emissions).

This measure requires that existing tanks storing volatile organic liquids be retrofitted to the BACTEA level by December 31, 1993.

Most tanks in Canada storing volatile organic liquids are now equipped with emission control/reduction equipment. This initiative aims at universalizing this practice, and possibly extending it to smaller tanks storing highly volatile organic liquids, or to tanks containing large quantities of moderately volatile liquids, both of which are potentially significant sources of emissions.

Emission reductions for this initiative were estimated using an overall average reduction efficiency of 80% for the petroleum refining sector tanks, and 62% for organic chemical industry sector tanks.

Recommendation:

° The provinces of British Columbia, Ontario, Quebec and New Brunswick establish, by December 31, 1991, existing tank retrofit plans and schedules to ensure completion of the retrofit programs by December 31, 1993. They may wish to use the multi-stakeholder task force charged with preparing a CCME guideline for new tanks storing volatile organic liquid (Initiative V302) to determine what BACTEA is for the different sizes of existing tanks containing liquids of different volatilities, and appropriate retrofit scheduling.

Initiative V607

Requirement that fugitive emission inventory and leak reduction programs be implemented at petroleum refineries in the LFV, WQC and SJA by 1993.

Petroleum refinery emissions in the LFV, WQC and SJA are estimated at 28.2 kilotonnes (3.2% of total VOC emissions) in the 1985 inventory, 57% of which would be fugitive emissions.

The U.S. EPA has established that relatively low cost programs can reduce uncontrolled fugitive emissions by 80%. New programs being developed in the U.S. rely on statistical methods to minimize the frequency of monitoring of the valves from which leaks occur and at the same time ensure maximum control of emissions. They also include the replacement of certain pieces of equipment if this is more cost effective than leak detection and repair programs.

The proposed measure requires that refineries put in place programs to better estimate fugitive emissions from their equipment, and followup with the corrective actions needed to reduce these leaks. The Canadian Petroleum Products Institute has indicated its support for such an initiative (CCPI 1990).

Emission reductions for this initiative were estimated using an average 80% reduction of fugitive emissions estimates for 2005.

Recommendation:

- The provinces of British Columbia, Ontario, Quebec and New Brunswick establish, by December 31, 1991, plans and schedules that require effective fugitive emission control programs be in place at existing refineries by December 31, 1992. Guidance for this initiative will be available from the code of practice to be developed for the control of fugitive emissions from new organic chemical plants (Initiative V304), and from the provincial fugitive emission control programs for existing organic chemical plants (Initiative V609).

Initiative V608

Retrofit of existing organic chemical plant processes in the LFV and WQC to BACTEA by 1996.

Emissions from the organic chemical industry in the LFV and WQC were estimated at 24.2 kilotonnes in 1985 (2.8% of total emissions), 40% of which were process emissions.

This measure requires that process emissions from existing organic chemical plants be controlled to the BACTEA level by December 31, 1996 in the LFV and WQC. Most plants already have emission control systems in place. Initiative V608 would bring some consistency to the level of efficiency of control measures within the industry.

This requirement parallels the proposed new source performance standard (NSPS) for organic chemical plants to be built in Canada after 1993 (Initiative V303).

Emission reductions for this Initiative have been estimated using an average reduction efficiency of 72% for 73% of forecast emissions for 2005.

Recommendation:

- The provinces of British Columbia, Ontario and Quebec establish retrofit standards and implementation scheduling for this initiative by December 31, 1992. Guidance on the definition of BACTEA for chemical processes used in Canada will be available from the multi-stakeholder task force charged with developing the NSPS for new plants as per Initiative V303. The provinces may wish to provide some flexibility to individual chemical plants by requiring that global emission limits be met on a plant basis if they are equivalent to the sum of individual process limits.

Initiate V609

Requirement that fugitive emission inventory and leak reduction programs be implemented at existing organic chemical plants in the LFV and WQC by 1993.

Emissions from the organic chemical industry were estimated at 24.2 kilotonnes (2.8% of total emissions in LFV and WQC) in 1985. A recent survey (Edwards 1990) indicates that about 42% of these emissions would be fugitive emissions.

The proposed measure requires that existing organic chemical plants located in the LFV and WQC put in place programs to better estimate the amount of fugitive emission released from their equipment, and to reduce these leaks by December 31, 1992. The Canadian Chemical Producers Association has already indicated its support of a similar initiative (CCPA 1990).

New programs being developed in the U.S. rely on statistical methods to minimize the frequency of monitoring of the potentially leaking equipment and at the same time ensure maximum control of emissions. They also include the replacement of certain pieces of equipment when new equipment is more cost effective. This should increase the cost effectiveness of this initiative in the future.

Emission reductions for this initiative were estimated using an average reduction efficiency of 40% for 75% of the fugitive emissions forecast for 2005.

Recommendation:

° The provinces of British Columbia, Ontario and Quebec establish retrofit implementation plans and schedules for this initiative by December 31, 1991. Guidance will be available from the code of practice for control of fugitive emissions from new organic chemical plants (Initiative V304), as well as from provincial fugitive emission control programs for petroleum refineries (Initiative V607).

Initiative V610

Retrofit of existing plastic processing plants in the LFV and WQC to BACTEA by 1996.

Emissions from the plastic processing industry were estimated at 12.1 kilotonnes (1.4% of total emissions in LFV and WQC) in the 1985 inventory.

This measure requires that existing plastic processing plants located in the LFV and WQC control their process emissions to the BACTEA level by December 31, 1995.

This requirement parallels the proposed national requirement for similar controls for new plants by 1995 (Initiative V305). The difference between these two initiatives is that new plants can usually install more efficient control technologies at lower costs than existing plants.

As for Initiative V305, the task force in charge of establishing the requirements for existing sources will have to establish which sources can be more cost effectively retrofitted in order to ensure the most emission reductions at the lowest costs. Small plants may have to be exempted if they do not contribute significantly to the emissions from this sector.

Emission reductions for this Initiative were estimated by using an average 90% reduction efficiency for 30% of the forecast emissions for 2005 for this sector.

Recommendation:

° the provinces of British Columbia, Ontario and Quebec establish retrofit limits, implementation plans and schedules by June 30, 1993. Guidance will be available from the multi-stakeholder task force charged with developing the NSPS guideline for future plants (Initiative V305).

Initiative V611

Retrofit of existing sulphate process in pulp and paper plants in the LFV, WQC and SJA to BACTEA by 1997.

Emissions from this source in LFV, WQC and SJA were estimated at 2.6 kilotonnes (0.3% of total emissions) in the 1985 inventory.

This measure requires that emissions from the sulphate (kraft) process units of existing pulp and paper mills in the LFV, WQC and SJA be captured and controlled to the BACTEA level by December 31, 1996.

This requirement parallels the proposed national requirements for similar new sources effective 1994 (Initiative V306). The difference between these two initiatives is that new plants can usually install more efficient control technologies at lower costs than existing plants.

Emissions reductions from plants using the sulphate process have been estimated by using an average 60% reduction efficiency applied to 50% of the forecast emissions for 2005. These numbers have been used for illustrative purposes only, since no data on control efficiency could be found.

Recommendation:

° The provinces of British Columbia, Ontario, Quebec and New Brunswick establish retrofit limits, implementation plans and schedules for this initiative by December 31, 1993. Guidance will be available from the multi-stakeholder task force charged with developing the NSPS guideline for future plants (Initiative V306).

Initiative V612

Retrofit of existing commercial/industrial surface coating application facilities in the LFV, WQC and SJA to BACTEA by 1996.

Initiative V612 requires that emissions from existing commercial and industrial coating operations be controlled to the BACTEA level in the LFV, WQC and SJA by December 31, 1995.

Commercial and industrial coating facility emissions were estimated at 79 kilotonnes for the LFV, WQC and SJA in the 1985 inventory (9% of total emissions). The proposed measure would reduce year 2005 emissions by 38.5 kilotonnes (10% of total emission reductions in the LFV, WQC and SJA).

The Montreal Urban Community already has a bylaw which requires 90% reduction of VOC emissions from certain of these facilities (Communaute Urbaine de Montreal 1987).

The definition of BACTEA could include substitution of regular coatings by water-base or low-solvent ones, thus giving more flexibility to facility operation. Small facilities or specific processes could be exempted if they do not contribute significantly to emissions from this sector.

Emission reductions for this initiative have been estimated using an average reduction efficiency of 90% applied to 60% of industrial application forecast emissions and 40% of commercial application forecast emissions in 2005.

Recommendation:

- The provinces of British Columbia, Ontario, Quebec and New Brunswick establish retrofit limits, implementation plans and schedules for this initiative by December 31, 1992. Guidance on the definition of BACTEA for different processes will be available from the multi-stakeholder task force charged with developing the NSPS guideline for future facilities (Initiative V307).

Initiative V613

Retrofit of existing rotogravure and flexography printers in the LFV and WQC to BACTEA by 1996.

Emissions from the printing sector in LFV and WQC were estimated at 11.4 kilotonnes (1.3% of total emissions) in the 1985 inventory. Rotogravure and flexography printing together represent 92% of all VOC emissions from the printing sector in the 1985 emission inventory.

About 50% of the rotogravure printing facilities and about 10% of the flexography printing facilities are estimated to have add-on controls (NO_x/VOC Work on Control Technologies 1990).

Add-on controls are capable of reducing VOC emissions from some printing facilities by 90%. Process modifications and ink reformulation can also significantly reduce emissions. The Montreal Urban Community has a bylaw requiring a 90% reduction of VOC emissions from certain of these facilities within its jurisdiction. (Communaute Urbaine de Montreal 1987)

Emission reductions for this initiative were estimated using an average reduction efficiency of 90% for 70% of the 2005 forecast emissions for the sector.

Recommendation:

- The provinces of British Columbia, Ontario and Quebec establish retrofit limits, implementation plans and schedules for this initiative by June 30, 1993. Guidance on potential retrofit emission limits will be available from the multi-stakeholder task force charged with developing the CCME code for new printing facilities (Initiative V308).

Initiative V614

Retrofit of existing commercial/industrial degreasing operations in the LFV and WQC to BACTEA by 1997.

Emissions from this sector were estimated at 10 kilotonnes for the LFV and WQC (1.1% of total emissions in LFV and WQC) in the 1985 inventory.

Degreasing operations are described under Initiative V309.

It is estimated that industry-wide average reductions of 20% by process changes and 30% by add-on controls can be achieved for existing facilities (NO_x/VOC Work Group on Control Technologies 1990). The Montreal Urban Community has established a bylaw requiring a 90% reduction of VOC emissions from metal part degreasing facilities.

Initiative V614 would be applied only to larger manufacturing units where centralized add-on controls can be retrofitted.

Emission reductions for this initiative were estimated using an average 50% reduction of 2005 forecast emissions for this sector.

Recommendation:

° The provinces of British Columbia, Ontario and Quebec establish retrofit limits, implementation plans and schedules for this initiative by June 30, 1994. Guidance on potential retrofit limits will be available from the multi-stakeholder task force charged with developing the CCME code for new facilities (Initiative V309).

Initiative V615

Retrofit of existing dry cleaning facilities in the LFV and WQC to BACTEA by 1997.

Emissions from dry cleaning facilities in 1985 were estimated at 7.4 kilotonnes in LFV and WQC (0.8% of total emissions in the LFV and WQC).

Dry cleaning operations and emission reduction opportunities are described under Initiative V310.

Initiative V615 requires:

- that all dry cleaning facility operators be certified,
- that the code of practice for operation and maintenance of dry cleaning facilities to be developed for Initiative V310 be distributed to all dry cleaning operators and be an important part of the certification program, and
- that large dry cleaning facilities be equipped to BACTEA levels by December 31, 1996.

Emission reductions for this initiative were estimated using an average 50% reduction efficiency applied to 50% of 2005 forecast emissions for this sector.

Recommendation:

- The provinces of British Columbia, Ontario and Quebec establish retrofit limits, implementation plans and schedules for this initiative by December 31, 1993. Guidance for this initiative will be available from the multi-stakeholder task force charged with developing the CCME code for new facilities (Initiative V310).

Initiative V616

Improved emission controls for wood waste burning in the LFV by 1995.

Wood waste burning is a significant source of VOCs in British Columbia. Emissions from this source were estimated to 6.2 kilotonnes in the LFV (5.5% of LFV total emissions) in 1985.

Emission reductions for this initiative were estimated by using a reduction efficiency of 50% applied to 2005 forecast emissions for this sector. This reduction efficiency was used for illustrative purposes only as no data are available yet on reduction opportunities for this source.

Proposed studies on emissions from this sector (Initiative S103) and on reduction opportunities (Initiative S302) will provide guidance for establishing retrofit schedules and emission limits for this initiative.

Recommendation:

- A retrofit schedule (within the 1995 target date) and retrofit emission limits be developed by the province of British Columbia in consultation with the appropriate stakeholders, by December 31, 1992.

VI.5 Description of Studies and Investigations for Phase II of the Plan

Emission Inventories and Forecasts (S100 Series)

Initiative S101

Streamline emission inventories with automated provincial reporting to establish a maximum one year lag time by 1993.

Currently, comprehensive national NO_x and VOC inventories are 3 to 4 years behind by the time they are published. This is unacceptable given today's electronic technologies.

Achieving more up-to-date emission inventories on a routine basis is an organizational problem, not a technical one. It requires more streamlining and automation up front so that all jurisdictions can input to a common system in a common format. It means acceptance by all jurisdictions of a common emission estimation methodology, with a forum to update the methodology as knowledge advances.

Initiative S101 involves getting the mechanisms and procedures in place to generate the previous years emission data within the current year. It requires cooperation by all jurisdictions to obtain and analyze essential data for developing inventories. Information such as industrial production statistics and statistics on the penetration of new technologies must be accessible in a timely manner from each jurisdiction. More work is required to ensure that all air emissions inventories carried out by regional, provincial and federal agencies are integrated, and that the database systems and inventory information are compatible and comparable.

Recommendation:

° Initiative S101 be coordinated by Environment Canada and use the mechanism of the current Inventories Subcommittee of the Federal/Provincial Advisory Committee on Air Quality.

Initiative S102

Update the national emission forecast annually, extending it to 2010, and update historical emission inventory data periodically to account for new information and methodologies.

Factors affecting emission forecasts are known to change rapidly. Recent evidence of this is the change in NO_x emissions from heavy duty vehicles as a result of running the new MOBILE4C model with it's revised assumptions on automobile performance, and the changes made in the forecast of NO_x emissions from gas-fired compressor engines as a result of new assumptions on the effectiveness of current NO_x control regulations. Similarly, major changes can occur in NO_x emissions from power plants as electricity demand, economic growth, energy supply options and import/export assumptions change. New information is continually being acquired on the use and penetration of emission control technologies, which is key to NO_x and VOC emission projections for all sectors.

Both current emissions and forecast emissions are fundamental to designing emission control programs. Data for the reference or base year (in this case, 1985) needs to be periodically updated to ensure an accurate comparison between current and historical emission levels.

Recommendation:

° Updated NO_x and VOC forecasts be prepared annually under Environment Canada coordination, with May of each year targetted as the delivery date. Each annual forecast should cover no less than a 15 year forecast period.

Initiative S103

Conduct emission surveys for the pulp and paper, plastics processing and wood transformation sectors.

Emissions from these sectors are based on generic emission factors. Individual plant emissions are not available in most cases.

There is need for more accurate emission data in order to establish the reductions that could be made and where they would take place. These data are needed by the end of 1991 in order to maintain the proposed timing for the application of controls.

Recommendation:

- ° Surveys for the pulp and paper and plastics processing sectors be conducted by Environment Canada.
- ° A survey for the wood transformation sector be conducted by the British Columbia Ministry of the Environment, since the preliminary data indicate most emissions from this sector are released in that province.

Initiative S104

Develop a more accurate data base on emissions from products containing solvents (coatings and other consumer products, pesticides, etc...)

Solvent use is estimated to be the largest source of VOCs nationally, and will be even more prominent as VOC emissions from the other dominant source, motor vehicles, declines.

Improved inventories of VOC emissions are needed for virtually all solvent use categories. Priority should be given to paints and coatings, general solvent use, glues and adhesives, and consummer products categories.

Additional solvent control is expected to be a focus in Phase II of the Plan. The data obtained under Initiative S104 will provide the bases for selecting solvent use categories for control, and for designing a better VOC control program.

Recommendation:

- ° Environment Canada, in collaboration with the provinces, conduct the studies needed to determine more accurate emission data for significant solvent use categories before December 31, 1992.

Initiative S105

Determine the number, spatial distribution and usage rates of off-road vehicles.

Most emission data for off-road sources is derived from fuel use statistics and antiquated fuel related emission factors found in the U.S. EPA emission factor compilation, AP-42. Also, the present information on the number, spacial distribution and use of off-road equipment is non-existent or woefully inadequate for most off-road emission sources. While there is a good deal of data available on the number and location of farm tractors in Canada from the national census, very little data exists on the number, type and location of other off-road equipment. This quality of data may be adequate for developing overall yearly inventories, but is inadequate for estimating the cost and benefits of regulations.

There is a need to identify the number of, and usage rates for, all mobile sources and internal combustion engines, in order to be able to use information on emission rates that will become available as a result of studies in support of regulations in the U.S.

Recommendation:

- Environment Canada conduct the reference studies with particular emphasis on spatial distribution in ozone non-attainment areas where emission caps may eventually be established.

Initiative S106

Prepare refined sets of emission inventory data for the WQC with spatial resolution suitable for oxidants modelling.

Detailed NO_x and VOC emission data with a small spatial resolution has already been generated for the Lower Fraser Valley. Data needs to be developed for the WQC with spatial resolution compatible with the input data requirements of the most promising regional and urban oxidants models. It is generally accepted that model grid sizes in the order of 20 km square for regional oxidant modelling and 2-10 km square for urban area oxidant modelling are required. (NO_x/VOC Work Group on Modelling 1990).

Recommendation:

- Environment Canada, in collarobation with Ontario and Quebec, develop appropriate NO_x and VOC emission data, by December 31, 1991, to model ozone episodes effectively in the WQC.

Ambient Air Quality Modelling (S200 Series)

Initiative S201

Analyze available ambient air monitoring data to obtain additional information on ozone episode characteristics.

In addition to further oxidants modelling, it is believed that much more can be learned by further analysis of ambient air quality and meteorological data already available.

Initiative S201 involves the extraction, analysis and presentation of available data for Canada and U.S. border areas to obtain additional insight on transboundary fluxes of NO_x, VOCs and O_3; to determine episode characteristics as they track through regions; to establish regional diurnal O_3 profiles during typical episodes; and to provide other information that will improve the general understanding of ground-level ozone. This analysis will also attempt to explain the discrepancy between VOC/NO_x ratios calculated from emission inventories and VOC/NO_x ratios found in ambient air.

Recommendation:

- Environment Canada, in collaboration with affected provinces, complete the analysis for this initiative by December 31, 1991.

Initiative S202

Expand the ambient air monitoring network for NO_x, VOC and O_3 with emphasis on rural/regional monitoring.

In order to determine the effectiveness of the NO_x/VOC Management Plan control initiatives, it will be vital to have a national trend database on ambient ozone, NO_x and VOC levels. Data should be available for both rural and urban areas and although the emphasis should be on the areas currently experiencing the most severe ozone concentrations, data will also be required for areas with moderate levels and for areas with no current information. Data on changes in transboundary flows of NO_x, VOCs and ozone is also needed.

The current urban ozone and NO_x monitoring database is considered adequate; some urban VOC monitoring is also underway. An extensive rural ozone monitoring network exists in the WQC and LFV areas, but no rural NO_x or VOC monitoring data is available.

This initiative will expand the rural/regional ozone monitoring program to include the prairie provinces, and improve coverage in the Atlantic provinces, WQC and LFV. A rural NO_x/VOC monitoring program will be initiated, with emphasis on the areas with highest ozone levels. Urban VOC monitoring will be expanded and enhanced. A routine program of aircraft flights in the WQC will assist the building of a trend data base of ozone/NO_x/VOC levels in the lower troposphere.

The expanded monitoring network will be developed with an emphasis on O_3, NO_x and VOC trend determinations, and on characterizing transboundary flows. The data requirements of currently available photochemical models will also be a major consideration in determining species to be measured.

Recommendation:

° Environment Canada, in collaboration with the provinces, establish the expanded monitoring network by December 31, 1993.

Initiative S203

Obtain better information on the transboundary flow of NO_x, VOCs and ozone, and on the transport of these pollutants into various segments of the LFV, WQC and SAR.

There is currently very little data available on the proportion of NO_x, VOCs and O_3 in the ambient air of different segments of the WQC, LFV and SAR that originates from the United States during typical ozone episodes. This is particularly true for ambient air concentrations during the daytime.

Initiative S203 involves obtaining better information on diurnal variations of ambient air NO_x and VOCs; analysis of reaction rates and transport distances for NO_x, VOCs and ozone during selected historical events; prediction of how much of each substance is likely to remain in a reactive form at different Canadian locations, analyses of whether low level sources of NO_x and VOCs are likely to be transported long distances in a reactive form; and prediction of how much NO_x is likely to enter Canada in the form of NO_2 from distant elevated sources, such as power plants.

Recommendation:

- Environment Canada conduct the above work in collaboration with provinces affected by transboundary flow, with a target date for completion of December 31, 1991.

Initiative S204

Prepare refined meteorological data sets for the WQC and LFV with spatial resolution to facilitate oxidants modelling.

There is a lack of meteorological data for the LFV and WQC on a suitable grid size for oxidant modelling. In the WQC, for example, most meteorological data is for the 127 km square grid used for the ADOM model. It is generally agreed that for effective oxidant modelling, a grid size not greater than 20 km square is needed in regional settings, with even finer resolution in urban areas.

Recommendation:

- Environment Canada develop meteorological data, by June 30, 1991, on an appropriate grid size for the WQC and LFV modelling domains.

Initiative S205

Set up and run appropriate scale oxidants models for the LFV and WQC preferrably with grid sizes for episode modelling not greater than 20 km X 20 km for rural areas and 5 km X 5 km for urban areas.

To date, there has been very limited oxidant modelling work conducted in the LFV and WQC. Better modelling capability will be needed to determine cause and effect relationships for control measures contemplated for Phase II of the Plan. Particularly important in such modelling will be use of spatial resolutions small enough to enable accurate simulation of oxidant forming reaction rates and ground-level ozone concentrations during episodes.

Initiative S205 involves (1) in the short term (by June, 1991) extending the Regional Oxidants Model (ROM) being run by the U.S. EPA for the northeastern states into Canada and completing selected model runs with different NO_x and VOC control levels in Canada and (2) in the longer term (by June, 1993), establishing an appropriate practical operating model for at least the Lower Fraser Valley and Windsor-Quebec City Corridor regions, and completing model runs to better predict the near-field and far-field effects of NO_x and VOC controls in different parts of these regions. These will include runs with different boundary condition assumptions to reflect predicted trends in the transboundary flow of NO_x, VOCs and ozone during episodes as a result of U.S. control programs.

Recommendation:

- Environment Canada and the provinces of British Columbia, Ontario and Quebec reach agreement on the appropriate agencies to lead the modelling efforts in each region.

- The lead agencies identified conduct the appropriate oxidants modelling within the specified time frames.

Initiative S206

Evaluate current information on health effects at different ozone exposure concentrations and times, determine exposure levels in Canada and develop a position on a 6-8 hour standard for ozone exposure.

There is growing concern over lung structure damage from chronic exposure to elevated ozone levels. A 6-8 hour ambient air ozone standard may be a better criteria for estimating the potential extent of this kind of health effect in key ozone problem areas than the current 1 hour standard.

Initiative S206 involves a review of all available studies worldwide on chronic health effects from ozone and the frequency, duration and concentrations of ozone exposures involved. These will be compared with ozone exposures in various Canadian regional settings. A position will be developed on the desirability and concentration level of a 6-8 hour ozone standard for Canada. This proposal will be put forward to the Federal/Provincial Advisory Committee on Air Quality for consideration and possible adoption.

Recommendation:

- Health and Welfare Canada develop a position on a 6-8 ozone standard, in consultation with provincial health departments and other interested stakeholders, by December, 1992.

Initiative S207

Evaluate current information on ozone damage to vegetation and develop a position on the form and level of an ambient ozone standard to protect vegetation.

The most recent information available on vegetation damage from ozone suggests that duration of exposure to ozone levels above the current 1 hour objective of 82 ppb may be a better indicator of potential vegetation damage than a lower level seasonal mean ozone standard.

All available information on vegetation damage cause and effect will be examined and a proposal will be put forward to the Federal/Provincial Advisory Committee on Air Quality on the form and level of an ambient ozone standard to protect vegetation.

Recommendation:

- Agriculture Canada, in consultation with provincial departments of agriculture and other interested stakeholders, develop a position on an ozone standard to protect vegetation, by December 31, 1992.

Technologies, Control Options and Costs (S300 Series)

Initiative S301

Refine the cost estimates for control of VOC emissions from major sources.

Current cost estimates for the control of major sources of VOCs are mostly based on U.S. data. In some cases, the data are more than five years old. The effect of colder climate requirements on cost has not been taken into account. All these factors require further study.

Another aspect of the cost of control which has not been sufficiently explored for major sources is the relationship between effectiveness of a given measure and the size of the source being regulated.

It is expected that relevant industrial sectors will fully cooperate and substantially contribute to the financing of these studies.

Recommendation:

- Environment Canada coordinate these studies with a target date for completion of December 31, 1991.

Initiative S302

Evaluate the type and extent of VOC emission controls currently employed in the plastics processing, pulp and paper and wood transformation industries.

Preliminary work in this area (NO_x/VOC Workgroup on Control Technologies 1990) has not been able to idendify clearly the control techniques currently employed in Canada or elsewhere for these sectors.

The Plan calls for controls on these sources starting in 1993. Control technologies available need to be identified to establish the reductions achievable as well as the cost effectiveness of these measures.

These studies could be conducted in parallel with Initiative S103.

Recommendation:

- Environment Canada coordiante these studies with target dates for completion of December 31, 1991.

Initiative S303

Conduct periodic reviews and joint government/industry R&D on advanced combustion and NO_x *emission control technologies.*

Rapid development of new combustion processes and flue gas cleanup technologies for NO_x is expected over the next decade, aided by efforts in industrialized countries around the world to reduce NO_x, SO_2 and CO_2 emissions. Technologies for the control of one pollutant will often affect emissions of other pollutants.

Initiative S303 will involve a continuing review during the next 5 years of new combustion process and NO_x control technology developments, with particular attention to those that have multi-pollutant control potential. This evaluation will include stage of development, costs and suitability for Canadian industries. In addition, joint government industry research and demonstration will be conducted for selected technologies to increase industry and regulatory agency knowledge and awareness of opportunities, and hopefully influence the adoption of these advanced technologies by the Canadian market.

Recommendation:

° Environment Canada and Energy, Mines and Resources Canada jointly establish and conduct a combustion and flue gas cleanup research program, in collaboration with industry, over the 1991-95 period.

Initiative S304

Evaluate the extent of current control and product substitution in all major solvent use categories.

A major weakness in the current inventory of VOC emissions from solvent use is a lack of information on the extent to which emission control technologies/options in the different solvent use categories are applied. In addition, information on product substitution plans already being contemplated by industry has not been obtained and analyzed, although such information is pertinent to evaluation of potential VOC control opportunities.

Initiative S304 will involve surveys of selected solvent use categories to better characterize current practices and intentions of industry. This work will be completed by December 31, 1991.

Recommendation:

° Environment Canada coordinate these surveys with a target date for completion of December 31, 1991.

Initiative S305

Evaluate the additional control and product substitution options available for major solvent use categories.

One of the reasons why the Plan calls for only modest reductions in VOC emissions from solvent use is that there is considerable uncertainty on options available and the rate at which they could be implemented in the various solvent use categories.

Initiative S305 will entail an in-depth evaluation of both currently available and developing VOC emission control and product substitution options, the development of reasonable projections on how fast they could be applied, and development of proposals to stimulate their adoption.

This evaluation will parallel and take advantage of information available from the 3-year study on consumer products called for in the amended U.S. Clean Air Act.

Recommendation:

- Environment Canada conduct this evaluation in consultation with affected industries, with a target date for completion of December 31, 1991.

Initiative S306

Evaluate measures planned or implemented under the greenhouse gas control program, and their implications for NO_x and VOC emissions.

Many of the options available to reduce greenhouse gas emissions will also reduce NO_x and VOC emissions, particularly NO_x emissions. There is a need for ongoing review and periodic evaluation of initiatives to control greenhouse gases over the next 4 years, so that the specifics of measures in the Phase 1 plan as well as adjustments to the Plan in 1994 take full account of, and are complementary to, the greenhouse gas control program. The annual updates to NO_x and VOC emission forecasts will partially address this issue. However, to better appreciate multi-pollutant reduction opportunities, many potential greenhouse gas control initiatives will require specific evaluation with respect to implications for NO_x and VOC emissions.

Initiative S306 will entail selected evaluations as greenhouse gas control initiatives become known, so that an up-to-date analysis of the interface between the two issues can be brought forward when discussions on Phase II of the Plan begin.

Recommendation:

- Environment Canada conduct this evaluation, in consultation with Energy, Mines and Resources Canada and provinces, as pertinent information on the greenhouse gas control program becomes available.

Initiative S307

Analyze Canadian passenger and goods transport networks to determine potential to reduce CO_2, NO_x and VOCs by intermodal shifts on major transportation arteries.

Transportation is a major source of VOC and NO_x emissions in urban areas of Canada. Tailpipe emission standards have been the preferred way to address this source up to now. Another means of reducing emissions from the transportation sector is to improve the transportation network by ensuring that passengers and goods are transported in a less polluting fashion.

Initiative S307 will entail an in-depth analysis of current passenger and goods transport networks to determine potential improvements that can be made from an environmental perspective, what the associated emission reductions would be, what measures would be needed to facilitate the occurrence of these changes, and their costs.

Recommendation:

- ° Transport Canada and Energy, Mines and Resources Canada conduct this study with a target date for completion of December 31, 1991.

Initiative S308

Evaluate the feasibility, and merits with respect to NO_x/VOC reduction, of a retrofit building code and labelling program for existing buildings.

While the energy efficiency provisions to be included in building codes will affect the energy and emission performance of buildings yet to be completed, the majority of residential, commercial and industrial building stock that will be in use between now and 2005 already exists. A concerted attempt will be made to identify the technical and economic potential for emissions and energy reduction in existing buildings and to develop model retrofit building codes and labelling systems to ensure that inefficient buildings can be identified and remedied.

Recommendation:

- ° Energy, Mines and Resources Canada conduct this evaluation in collaboration with provinces, with a target date for completion of December 31, 1992.

Initiative S309

Evaluate the merits of NO_x/VOC emission trading for ozone control and, if favoured by a province or provinces, develop a model framework for implementation.

Emission trading has been identified as a potential option to the traditional regulatory approach. For ozone control it would appear to have most potential for application in limited geographic regions where there are existing ozone problems and a need for retrofitting of emission controls on numerous stationary sources.

Application of emission trading to NO_x and VOC emissions for the purpose of ozone control is potentially much more complex than its application for control of SO_2 or CO_2. To control ozone, two precursor pollutants are involved rather than a single primary pollutant. Each precursor pollutant affects ozone formation on a different geographic scale. There are many small emission sources that would have to be examined and permitted individually. There is also a combination of mobile and stationary sources of emissions and of federal and provincial regulatory responsibilities in each geographic region.

Other uncertainties, such as the amount of administrative burden vis-a-vis traditional control methods and consistency with established provincial regulatory policies, also need to be considered. Initiative S308 will examine all relevent aspects of emission trading for ozone control and, if stakeholders concur, develop a model implementation framework for use by provinces by December 31, 1992.

Recommendation:

- Environment Canada conduct this evaluation, in collaboration with interested provinces, industries and other stakeholders, and if required, develop the model implementation framework by December 31, 1992.

U.S. Emission Control (S400 Series)

Initiative S401

Analyze the new U.S. NO_x *control program for* NO_x *reductions in selected regions (Ohio Valley, Great Lakes, eastern seaboard, etc.) between now and 2010.*

The Plan recognizes that ozone air quality objectives in all regions of Canada will not be attained unless significant NO_x and VOC reductions occur in the United States. Because Canada is most affected by pollutants eminating from a few select regions of the U.S., better understanding of the trends in emissions in these regions over the next 15-20 years is imperative. For example, there is a concentration of power plants in the Ohio Valley which collectively produce more NO_x than is produced nationwide in Canada from all sources.

Initiative S401 entails an evaluation of American trends in NO_x emissions in selected regions as a result of anticipated U.S. control actions. It will begin within 6 months after passage of the proposed U.S. Clean Air Act amendments (latest anticipated timing is December, 1990), with a report in 6 months from that date and a subsequent update in 1993 before discussions begin on Phase II of the Plan.

Recommendation:

- Environment Canada conduct this analysis, in consultation with provinces affected by pollutants transported from the U.S., within the timeframe indicated above.

Initiative S402

Analyze measures in, and track implementation of, national Clean Air Act provisions applicable and State Implementation Plans (SIPs) in selected ozone non-attainment areas in the U.S. (Seattle, Michigan, Ohio, New York, etc.)

The regional implications of U.S. national ozone non-attainment measures and the success of certain SIPs are fundamental to improving air quality in some regions of Canada. It is important to understand what these are likely to achieve if fully implemented, and whether they are being implemented as planned, as lack of implementation has been a problem in the past. There may be opportunities to encourage emission reductions in areas of the U.S. of particular interest to Canada, and consideration of a lower ozone target level (i.e. 82 ppb) in border regions.

Initiative S402 entails an in-depth review of the measures proposed in provisions of the U.S. Clean Air Act and selected SIPs, and of the timing of their implementation. It will also estimate the VOC and regional ozone reductions that are likely to occur as a result of those measures.

Recommendation:

° Environment Canada conduct this analysis, in consultation with provinces affected by pollutants transported from the U.S. and with other intersted stakeholders, with a target date for completion of December 31, 1992.

VII POST-PLAN NO_x AND VOC EMISSIONS

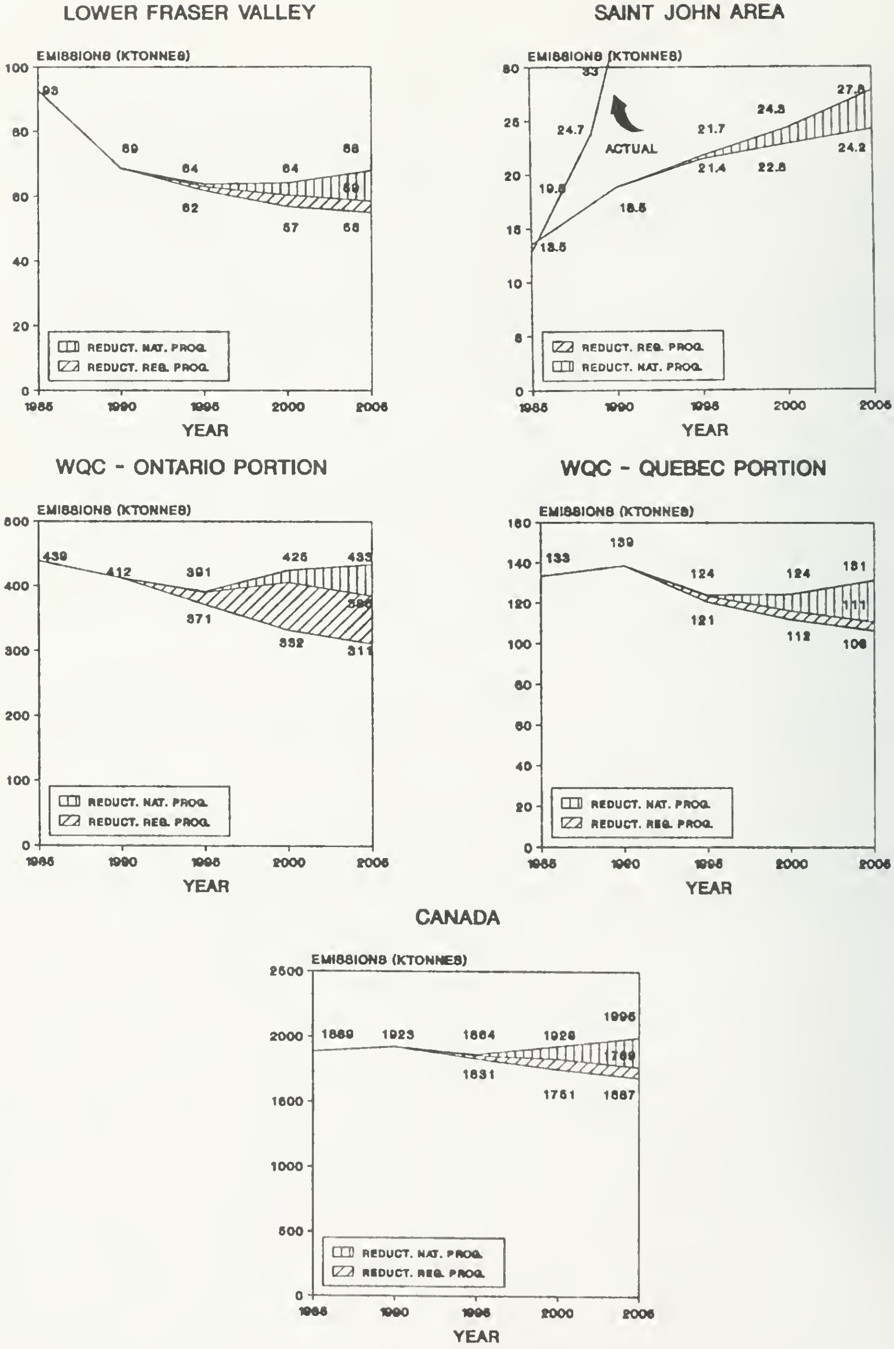
Projected emissions of NO_x and VOCs over the 1985 to 2005 period with and without implementation of the base prevention and illustrative remedial programs of the Phase I Plan are shown graphically in Figures 28 and 29. The figures also show the distribution between reductions achieved by national and regional control measures.

Tables 14 and 15 list estimated pre-plan and post-plan NO_x and VOC emissions in the year 2005. The tables also show the breakdown of reductions achieved through the national and the illustrative regional initiatives in each of the source categories. Source categories are listed nationally and for each of the three designated non-attainment areas in order of projected pre-Plan quantity of emission in 2005.

It is of interest to note the magnitude of the remaining emissions from the various sectors after both the national and the illustrative regional control initiatives have been applied. If additional NO_x control is contemplated, it would appear that in both the LFV and WQC, heavy duty vehicles, commercial/industrial fuel combustion, selected industrial processes and selected off-road diesel engine categories would be prime candidates. Some of the smaller source categories not dealt with in either the national or the illustrative regional programs, such as aircraft and marine, could also be considered for control.

In terms of additional opportunities for reducing VOC emissions, the focus would be on selected categories of solvent use, selected industrial processes, off-road gas, and marine. After implemention of the Plan, solvent use VOC emissions will be more than double the VOC emissions from any other source in both the WQC and LFV.

To provide an additional perspective on the geographic implications of the Plan, emission reductions and post-Plan emissions are presented by province in Tables 16 and 17. Also shown in those tables is the percentage by which each province, and the ozone problem regions, will be below the 1985 emission levels in 2005, with the full implementation of the national prevention and the illustrative regional programs of the Phase 1 Plan.



LOWER FRASER VALLEY

SAINT JOHN AREA

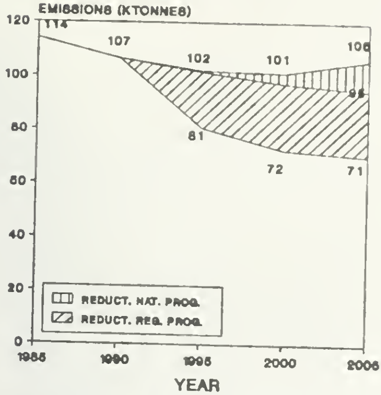
WQC - ONTARIO PORTION

WQC - QUEBEC PORTION

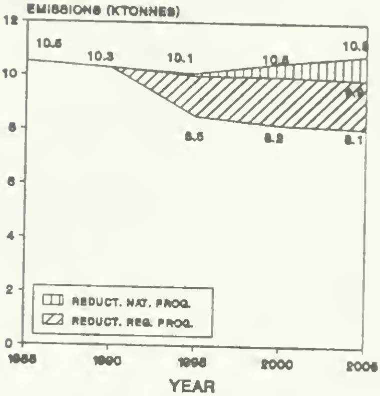
CANADA

FIGURE 28 PRE-PLAN AND POST-PLAN NO_x EMISSIONS - 1985-2005

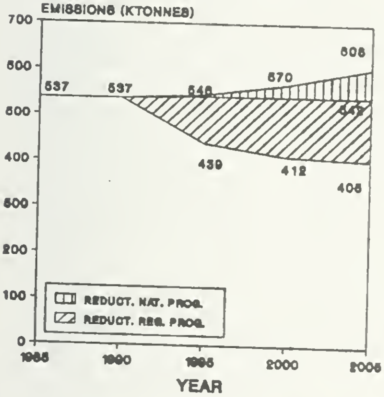
LOWER FRASER VALLEY



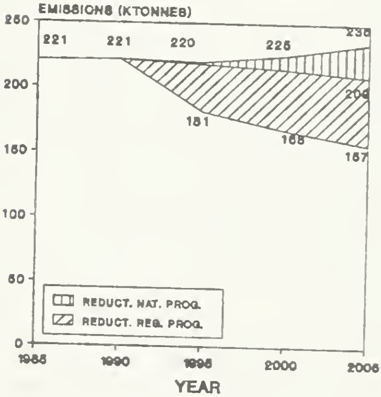
SAINT JOHN AREA



WQC - ONTARIO PORTION



WQC - QUEBEC PORTION



CANADA

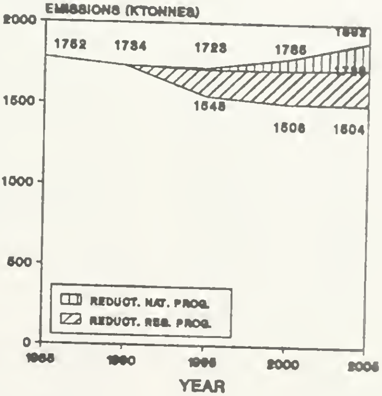


FIGURE 29 PRE-PLAN AND POST-PLAN VOC EMISSIONS - 1985-2005

TABLE 14 PRE-PLAN AND POST-PLAN NO_x EMISSIONS (KT/YR)

Area	1985	2005 Pre-Plan	2005 After National (Prevention) Initiatives	2005 After National & Illustrative Regional Initiatives
Lower Fraser Valley (LFV)				
Light Duty Vehicles/Trucks	34.4	16.5	12.1	11.4
Heavy Duty Vehicles	28.1	16.1	14.8	14.1
Comm/Ind. Fuel Combustion	9.2	12.2	9.4	9.1
Off-Road Diesel	6.4	8.1	7.7	7.7
Industrial Processes	3.7	5.9	5.9	4.9
Residential Fuel Combustion	1.9	1.8	1.6	1.6
Marine	1.0	1.6	1.6	1.6
Railroads	1.7	1.3	1.3	1.3
Power Generation	3.7	1.2	1.0	0.2
Aircraft	0.3	0.5	0.5	0.5
Other	2.3	2.6	2.6	2.6
	92.7	67.8	58.5	55.0
Windsor-Quebec Corridor (W-Q)				
Light Duty Vehicles/Trucks	196.8	111.1	81.2	76.8
Heavy Duty Vehicles	92.4	97.1	89.3	84.9
Power Generation	91.5	93.4	93.4	36.2
Comm/Ind. Fuel Combustion	58.6	83.1	56.5	53.7
Off-Road Diesel	43.3	64.6	61.1	61.1
Industrial Processes	34.3	55.4	55.4	46.0
Residential Fuel Combustion	17.9	15.7	14.1	14.1
Aircraft	9.6	13.0	13.0	13.0
Marine	10.7	12.5	12.5	12.5
Railroads	4.7	3.7	3.7	3.7
Other	12.4	15.1	15.1	15.1
	572.2	564.7	495.8	417.1
Saint John Area (SJA)				
Power Generation	3.2	15.7	13.4	13.4
Comm/Ind. Fuel Combustion	2.7	3.8	3.0	3.0
Industrial Processes	1.4	2.2	2.2	2.2
Heavy Duty Vehicles	1.9	2.2	2.0	2.0
Off-Road Diesel	1.2	1.7	1.7	1.7
Light Duty Vehicles/Trucks	2.3	1.1	0.8	0.8
Other	0.8	1.1	1.1	1.1
	13.5	27.8	24.2	24.2
National				
Power Generation	247.9	351.7	287.8	229.8
Off-Road Diesel	230.4	317.4	309.5	309.5
Heavy Duty Vehicles	285.2	260.8	239.9	234.8
Light Duty Vehicles/Trucks	453.1	238.2	174.2	169.1
Comm/Ind. Fuel Combustion	145.2	207.3	144.4	141.3
Natural Gas Industry	158.8	205.2	202.2	202.2
Industrial Processes	89.0	139.7	139.7	129.3
Railroads	132.1	113.0	113.0	113.0
Aircraft	33.4	42.3	42.3	42.3
Residential Fuel Combustion	41.5	36.9	33.2	33.2
Off-Road Gas	30.4	28.7	28.7	28.7
Marine	14.9	18.5	18.5	18.5
Other	25.0	35.7	35.7	35.7
	1886.9	1995.4	1769.1	1687.4

TABLE 15 PRE-PLAN AND POST-PLAN VOC EMISSIONS (KT/YR)

		2005		
Area	1985	Pre-Plan	After National (Prevention) Initiatives	After National & Illustrative Regional Initiatives
Lower Fraser Valley (LFV)				
Solvent Use	28.3	32.5	26.0	21.6
Light Duty Vehicles/Trucks	45.0	26.7	25.5	15.9
Industrial Processes	6.1	7.6	6.1	3.0
Marine	3.8	6.5	6.5	6.5
Gas Distribution	6.6.	6.1	6.1	0.7
Industrial Fuel Combustion	4.3	5.6	5.6	1.6
Heavy Duty Vehicles (HDVs)	6.5	3.2	3.2	3.2
Off-road Gas	2.8	3.0	3.0	3.0
Fuelwood Combustion	2.0	2.7	2.7	2.7
Aircraft	0.7	1.1	1.1	1.1
Other	7.9	9.9	9.9	9.9
	114.0	104.9	95.7	69.2
Windsor-Quebec Corridor (WQC)				
Solvent Use	263.3	327.1	261.1	216.0
Industrial Processes	85.2	131.0	115.7	81.7
Light Duty Vehicles/Trucks	236.1	165.0	157.3	98.4
Fuelwood Combustion	54.4	69.5	69.5	69.5
Gas Distribution	50.4	63.9	63.9	12.6
Off-road Gas	19.6	25.7	25.7	25.7
Heavy Duty Vehicles (HDVs)	13.8	17.1	17.1	17.1
Marine	11.9	11.9	11.9	11.9
Aircraft	3.0	4.1	4.1	4.1
Other	19.4	25.1	25.1	25.1
	757.1	840.4	751.4	562.0
Saint John Area (SJA)				
Solvent Use	2.3	2.6	2.1	1.9
Fuelwood Combustion	2.1	2.4	2.4	2.4
Industrial Processes	1.6	2.2	1.9	0.7
Light Duty Vehicles/Trucks	2.6	1.5	1.4	1.1
Gas Distribution	0.6	0.7	0.7	0.6
Heavy Duty Vehicles (HDVs)	0.4	0.4	0.4	0.4
Marine	0.3	0.3	0.3	0.3
Off-road Diesel	0.1	0.3	0.3	0.3
Off-road Gas	0.2	0.2	0.2	0.2
Other	0.3	0.2	0.2	0.2
	10.5	10.8	9.9	8.1
National				
Solvent Use	502.0	602.9	480.9	431.2
Light Duty Vehicles/Trucks	556.8	349.9	333.6	261.7
Industrial Processes	152.3	239.4	211.4	173.1
Fuelwood Combustion	107.7	132.7	132.7	132.7
Slash Burning	80.6	129.0	129.0	129.0
Gas Distribution	109.0	124.4	124.4	66.8
Off-road Gas	66.1	74.3	74.3	74.3
Industrial Fuel Combustion	49.5	63.9	63.9	59.9
Heavy Duty Vehicles (HDVs)	53.8	47.8	47.8	47.8
Off-road Diesel	23.4	34.8	34.8	34.8
Marine	27.9	31.5	31.5	31.5
Aircraft	10.1	13.2	13.2	13.2
Railroads	7.0	6.0	6.0	6.0
Other	36.2	42.1	42.1	42.1
	1782.4	1891.4	1725.6	1504.0

TABLE 16 PROVINCIAL NO_X EMISSION REDUCTIONS (KT/YR 2005)

Province/Territory	1985	Reductions in 2005[1]									2005 Pre-Plan	2005 Post-Plan	% Diff. From 1985	
		LDVs	HDVs	Off Rd. Diesel	Elect. Power	Nat. Gas	C/Ind. Fuel Comb.	Ind. Proc.	Res. Fuel Comb.	Total				
British Columbia	252.6	9.1	3.1	0.7	1.0	1.1	9.3	1.0	0.3	25.6	225.4	199.8	- 20.9	(LFV -40.7)
Alberta	440.3	6.6	2.0	1.4	35.8	0	8.5	0	0.7	55.0	528.3	473.3	+ 7.5	
Saskatchewan	155.6	3.1	1.8	0.5	9.5	1.8	3.3	0	0.2	20.2	165.5	145.3	- 6.6	
Manitoba	81.9	3.0	1.7	0.4	0.1	0	2.2	0	0.1	7.5	77.0	69.5	- 15.1	
Ontario	557.5	29.3	9.8	3.5	57.2	0.1	27.6	9.1	1.5	138.1	553.6	415.5	- 25.5	(WQC -27.1)
Quebec	222.8	13.1	4.5	0.9	0.5	0	10.4	0.3	0.4	30.1	218.3	188.2	- 15.5	
New Brunswick	46.4	1.5	0.9	0.1	11.6	0	1.9	0	0.1	16.1	80.7	64.6	+ 39.2	(SJA +79.3)[2]
Nova Scotia	74.3	1.9	1.3	0.1	4.0	0	1.4	0	0.2	8.9	82.9	74.0	0.0	
Prince Edward Island	5.6	0.3	0.2	<0.1	<0.1	0	<0.1	0	<0.1	0.5	5.4	4.9	- 12.5	
Newfoundland	33.7	1.0	0.6	0.1	0.9	0	1.3	0	0.1	4.0	36.2	32.2	- 4.5	
Yukon/N.W.T.	16.0	0.2	0.1	0.2	1.3	0	0.1	0	<0.1	2.0	22.1	20.1	+ 25.6	
CANADA	1886.9	69.1	26.0	7.9	121.9	3.0	66.0	10.4	3.7	308.0	1995.4	1687.4	- 10.6	
INITIATIVES		N301 N601	N302 N502	N303	N101 N305 N603	N308	N102 N306 N307 N603	N604 N605	N104					

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[1] The distribution of emission reductions by sector and province is based on the implementation of all emission control initiatives outlined in the base national prevention program and the illustrative regional remedial program for ozone non-attainment areas.

[2] 1985 was an abnormally low NO_x emissions year in the SJA with NO_x from power generation (the largest source) only about 30% of the level in 1988. Referencing the 1988 level would give a small reduction rather than the high percentage increase obtained by referencing 1985.

TABLE 17 PROVINCIAL VOC EMISSION REDUCTIONS (KT/YR - 2005)

		Reductions in 2005[1]										
Province/Territory	1985	LDVs	Gas Dist^n	Vol. Liq. Storage	Ind. Process /Comb.	Paints/ Coatings	Other Solvent Use	Total	2005 Pre-Plan	2005 Post-Plan	% Diff. From 1985	
British Columbia	294.4	11.9	5.4	2.1	8.6	9.0	7.7	44.7	304.5	259.8	- 11.8	(LFV -39.4)
Alberta	195.8	1.5	0	1.7	4.0	2.8	5.2	15.1	180.1	165.0	- 15.7	
Saskatchewan	82.9	0.8	0	0.3	0	1.2	2.4	4.7	73.7	69.0	- 16.8	
Manitoba	71.0	0.8	0	0	0.1	1.5	2.3	4.7	59.8	55.1	- 22.4	
Ontario	631.3	52.0	37.1	9.2	28.5	52.9	34.6	214.3	713.2	498.9	- 21.0	(WQC -25.8)
Quebec	355.8	16.6	14.3	3.3	10.4	26.0	17.1	87.6	392.6	305.0	- 14.3	
New Brunswick	45.4	1.9	0.4	0.5	1.1	1.2	1.6	6.7	47.9	41.2	- 9.3	(SJA - 23.2)
Nova Scotia	52.2	2.4	0.4	0.6	0	1.2	1.9	6.5	51.3	44.8	- 14.3	
Prince Edward Island	11.0	0.1	0	0	0	0.3	0.3	0.7	11.2	10.5	- 4.2	
Newfoundland	35.6	0.2	0	0	0	0.8	1.4	2.4	49.3	46.9	+ 31.8	
Yukon/N.W.T.	7.0	<0.1	0	0	0	0.1	0.2	0.3	8.3	8.0	+ 14.4	
CANADA	1782.4	88.2	57.6	17.7	52.6	97.1	74.6	387.8	1891.9	1504.1	- 15.6	
Initiatives		V301 V601 V602	V602 V603 V604 V605	V302 V606	V303 V304 V305 V306 V607 V608 V609 V610 V611 V616	V101 V307 V612	V102 V103 V104 V308 V309 V310 V613 V614 V615					

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[1] The distribution of emission reductions by sector and province is based on the implementation of all emission control initiatives outlined in the base national prevention program and the illustrative regional remedial program for ozone non-attainment areas.

VIII EFFECTIVENESS OF THE PLAN

VIII.1 Effectiveness in Resolving Domestic Ground-Level Ozone Problems

a) Peak Ozone Concentrations

In the absence of more detailed analysis with reliable oxidants models, estimates have been made of what the combined prevention and illustrative remedial programs in the Phase I Plan are likely to achieve in terms of ozone reduction in the three designated non-attainment areas. These estimates are based on the information contained in Section V and on general assumptions regarding local versus long range transport influence.

Two sets of estimated peak ozone reductions are provided. Table 18(a) contains predictions of post-Plan peak ozone concentrations in the selected areas, with no change in the amounts of NO_x, VOC and ozone imported from the United States. However, reductions in emissions of both NO_x and VOCs can be expected in the United States over the next 10-25 years from implementation of the amended U.S. Clean Air Act provisions. These reductions will vary in different parts of the United States depending on how far different regions need to reduce emissions to achieve attainment of the U.S. primary ambient air ozone standard (120 ppb), the distribution of major stationary NO_x sources such as power plants and heavy industry, and the specific provisions that are mandatory in each of the ozone non-attainment classifications.

Several reviews have been made of the percentage NO_x and VOC reductions that might be expected by implementing the amended Clean Air Act provisions (Wilson 1990, Possiel 1990). Based on these, the following NO_x and VOC emission reduction assumptions have been made for the purposes of predicting benefits in Canada of the combined Canadian and U.S. control programs for NO_x and VOCs:

Region:	% Reduction (2005) NO_x	 VOCs
U.S. Eastern Seaboard (Washington to Boston)	30	50
South and West of Lake Erie/Lake Ontario	30	38
Seattle Area	30	38

Table 18(b) contains estimates of reductions in ozone peaks in Canada resulting from with the combined effect of implementing the Plan and achieving the above NO_x and VOC reductions in the United States.

As shown in Table 18 (a), reductions in peak ozone levels ranging from no reduction at the southern end of the WQC to reductions up to 35% in the LFV are predicted if there were no change in the level of pollutants imported from the U.S. Depending on the extent of long range transport, ozone occurences above 82 ppb would be essentially eliminated up the Fraser Valley east of Vancouver. In other locations in all three regions, ozone peaks well above 82 ppb will still occur. However, the frequency of exceedances and the total number of hours per year above the maximum acceptable O_3 objective should be substantially reduced as discussed in the next section.

TABLE 18 PREDICTED PEAK OZONE CONCENTRATIONS AFTER IMPLEMENTING THE MANAGEMENT PLAN

(a) With Current Levels of NOx, VOCs and O_3 Imported from the United States

Region	Plan Emission Reductions Below 1985 (%)		U.S. Emission Reductions in Import Regions (%)		Approx. Percent O_3 Reduction	Peak Ozone Concentrations (ppb)	
	NOx	VOC[1]	NOx	VOC		Pre-Plan (1985)	Post-Plan (2005)
Lower Fraser Valley (LFV)	41	40 (50)	No Change				
- Vancouver					20-30	60-210	45-160
- Chilliwack					20-30	80-120	60-90
Windsor-Quebec Corridor (WQC)	27	25 (31)	No Change				
- Windsor					0	100-160	100-160
- Toronto					10-15	80-190	70-170
- Stouffville					10-15	80-160	70-140
- Montreal					15-20	60-180	50-150
- Quebec					15-20	60-160	50-130
Southern Atlantic Region (SAR)			No Change				
- Saint John Area (SJA)	+79[2]	23 (29)			0-10	80-100	75-90
- Kejimkujik	0	9 (11)			0	80-150	80-150

(b) With Reduced Levels Levels of NOx, VOCs and O^3 Imported from the United States

Region	Plan Emission Reductions Below 1985 (%)		U.S. Emission Reductions in Import Regions (%)		Approx. Percent O_3 Reduction	Peak Ozone Concentrations (ppb)	
	NOx	VOC[1]	NOx	VOC		Pre-Plan (1985)	Post-Plan (2005)
Lower Fraser Valley (LFV)	41	40 (50)	30	38 (47)			
- Vancouver					20-30	60-210	45-160
- Chilliwack					25-35	80-120	55-85
Windsor-Quebec Corridor (WQC)	27	25 (31)	30	38 (47)			
- Windsor					15-20	100-160	80-130
- Toronto					25-30	80-190	60-140
- Montreal					20-25	60-180	50-140
- Quebec					20-25	60-160	50-125
Southern Atlantic Region (SAR)							
- Saint John	+79[2]	23 (29)	30	50 (62)	10-30	80-100	60-80
- Kejimkujik	0	9 (11)			10-20	80-150	70-130

[1] % VOC emission reductions shown in brackets () have been used to estimate O_3 reduction. They are 25% higher than the annual average to account for greater reduction during the daytime in summer due to the seasonal nature of some VOC controls such as fuel volatility reduction.

[2] See footnote Table 11. Ozone reduction is based on no change in NO_x emissions (0% reduction) which is more representative.

The picture is substantially improved in the WQC and SAR when potential reductions in pollutants imported from the United States are considered. With the levels of reductions in imported pollutants assumed in Table 18(b), the highest ozone peaks in the Windsor area of the WQC are reduced by about 25% from 160 ppb to 120 ppb, the level of the U.S. primary O_3 standard. Improvements also occur further along the corridor. Peaks in the SAR would be brought down to the 82 ppb range in the highest ozone area (Kejimkujik) and below this level elsewhere in the SAR. There would be little change in the Vancouver area of the LFV.

b) Hours Above Maximum Acceptable Ozone Level

Relationships between hours greater than 82 ppb and maximum ozone have been examined for the GVRD-LFV, for Ontario and for Quebec, using data for all sites and all years (see Figures 30 and 31). Although there is considerable scatter in the data, the three graphs in Figures 30 and 31 show that there is a linear relationship between hrs > 82 ppb and maximum ozone. Table 19 was constructed using the equations shown on these graphs and indicates that for a given percentage reduction in peak ozone concentration a greater percentage reduction in hours > 82 ppb will occur.

TABLE 19 RELATIONSHIP BETWEEN CHANGE IN MAX. OZONE VS CHANGE IN HRS>82 ppb (BASED ON EQUATIONS FROM FIGURES 28 AND 29)

MAX1 (ppm)	MAX2 (ppm)	% CHANGE		No.Hrs1	No.Hrs2	% CHANGE
	Quebec 1983-1989					
0.160	0.128	-20%		66	41	-38%
0.140	0.112	-20%		50	28	-44%
0.120	0.096	-20%		34	16	-55%
0.120	0.084	-30%		34	6	-83%
0.110	0.088	-20%		27	9	-65%
	Ontario 1983-1989					
0.180	0.126	-30%		137	70	-49%
0.160	0.128	-20%		112	72	-36%
0.140	0.112	-20%		87	52	-40%
0.120	0.096	-20%		62	33	-48%
0.120	0.084	-30%		62	17	-73%
0.110	0.088	-20%		50	23	-55%
	GVRD-Fraser Valley 1983-1989					
0.180	0.126	-30%		31	15	-51%
0.160	0.112	-30%		25	11	-56%
0.160	0.128	-20%		25	16	-37%
0.140	0.112	-20%		19	11	-43%
0.120	0.096	-20%		13	6	-53%
0.120	0.084	-30%		13	3	-79%
0.100	0.090	-10%		8	5	-39%

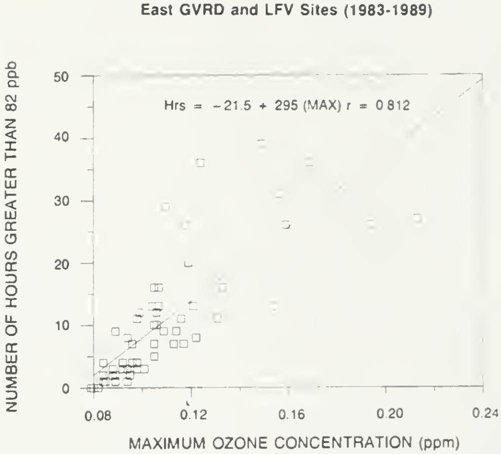


FIGURE 30 RELATIONSHIP BETWEEN MAXIMUM OZONE AND HOURS 82 ppb — GVRD/LFV

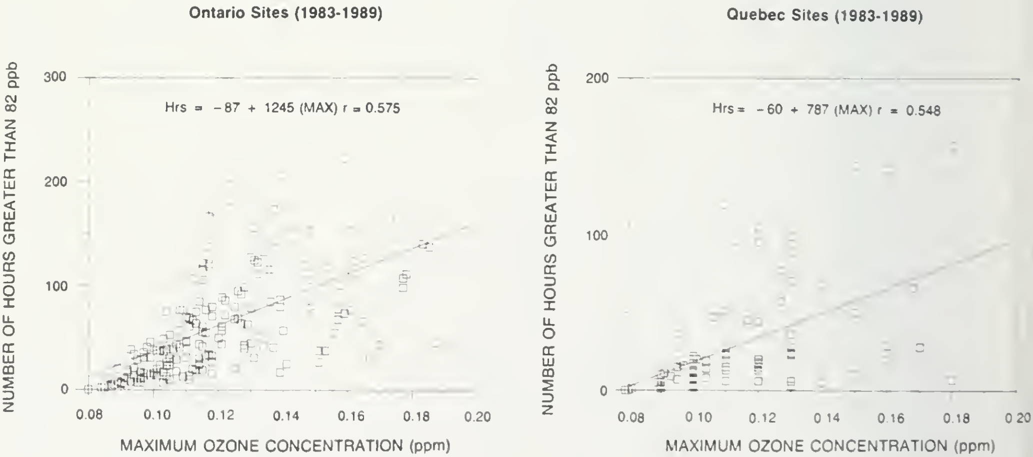


FIGURE 31 RELATIONSHIP BETWEEN MAXIMUM OZONE AND HOURS 82 ppb — WQC

These relationships were applied to post-Plan ozone peaks (average of 3 highest years) at various locations to obtain hours above 82 ppb that might be expected in a typical high ozone year after implementing the Plan. The results of this analysis are presented in Table 20 for cases with and without NO_x and VOC reductions in the United States.

The information in Table 20 suggests that the percentage reduction in duration of exposure to ozone levels above 82 ppb should be much greater than the percentage reduction in ozone peaks (Table 18). In the LFV, reductions in hours >82 ppb are estimated at 40 to 100% depending on location. Emission reductions in the U.S. would contribute some additional reductions in duration of exposure at locations downwind from Vancouver along the Fraser River Valley. With both Canadian and U.S. controls, duration of exposures to levels above 82 ppb in these areas would be minimal.

In the WQC, there would be no reduction in hours >82 ppb in the Windsor area without emission reductions in the U.S., but elswhere down the corridor the Canadian emission controls alone would reduce the hours >82 ppb by 20-50%, depending on location. Adding the influence of the U.S. control program provides major additional benefits to Canada. It results in a reduction in hours >82 ppb in the Windsor area of 40-50% where no reduction would otherwise occur, and increases in the reduction in hours >82 ppb at other locations along the corridor to the 45-90% range, up from the 20-50% reduction predicted for Canadian controls alone.

In the SAR, the effect of U.S. NO_x and VOC controls is estimated to be greatest in southern Nova Scotia, where the highest ozone levels have been recorded. The U.S. controls are estimated to double the reduction in hours >82 ppb from a range of 15-30% with Canadian controls alone to 30-60%.

As previously discussed, the statistic "total hours greater than 82 ppb" is also a potentially useful indicator of the severity of ozone effects on vegetation. Although the quantitative relationship between percentage reduction in hours of ozone over 82 ppb and increased crop yield is not currently available, it is certain that there will be substantial agricultural benefits associated with reductions in ozone. These benefits may also be realized for natural ecosystems.

VIII.2 Effectiveness in Reducing Emissions of Toxic VOCs

Many of the VOC sources identified for control under the Plan contain VOC species that are of concern because of known or suspected toxicity. More than half of the substances on the Priority Substances List (PSL) of the Canadian Environmental Protection Act and now under assessment for toxicity are VOCs. Examples are benzene, toluene and xylene (constitutents of gasoline) and numerous solvents used in such processes as dry cleaning, surface coating and industrial degreasing. Benzene occurs in emissions from automobiles, refineries, gasoline distribution and organic chemical plants, all of which are identified for control in the Plan. Similarly, control measures are proposed for a number of solvent use categories.

TABLE 20 PREDICTED REDUCTION IN OZONE HOURS > 82 ppb

(a) With Current Levels of NOx, VOCs and O_3 Imported from the United States

Region	Approx. Percent O_3 Reduction	Peak Ozone Conc (ppb) (Avg. 3 High Yrs) Pre-Plan (1985)	Peak Ozone Conc (ppb) (Avg. 3 High Yrs) Post-Plan (2005)	Reduction Hours >82ppb (%)	Annual Hours >82 ppb (Avg. 3 High Yrs) Pre-Plan	Annual Hours >82 ppb (Avg. 3 High Yrs) Post-Plan
Lower Fraser Valley (LFV)						
- Vancouver	20-30	147	100-120	40-59	22	9-13
- Chilliwack	20-30	111	80-90	58-100	11	0-5
Windsor-Quebec Corridor (WQC)						
- Windsor	0	146	146	0	155	155
- Toronto	10-15	164	140-150	17-26	117	87-97
- Stouffville	10-15	132	110-120	29-44	97	55-69
- Montreal	15-20	143	110-120	32-43	53	30-36
- Quebec	15-20	117	90-100	43-47	32	14-18
Southern Atlantic Region (SAR)						
- Saint John Area (SJA)	10-20	93	75-85	55-100	13	0-6
- Kejimkujik	5-10	113	100-110	15-31	29	20-24

(b) With Reduced Levels Levels of NOx, VOCs and O_3 Imported from the United States

Region	Approx. Percent O_3 Reduction	Peak Ozone Conc (ppb) (Avg. 3 High Yrs) Pre-Plan (1985)	Peak Ozone Conc (ppb) (Avg. 3 High Yrs) Post-Plan (2005)	Reduction Hours >82 ppb (%)	Annual Hours >82 ppb (Avg. 3 High Yrs) Pre-Plan	Annual Hours >82 ppb (Avg. 3 High Yrs) Post-Plan
Lower Fraser Valley (LFV)						
- Vancouver	20-30	147	100-120	40-59	22	9-13
- Chilliwack	25-35	111	70-85	73-100	11	0-3
Windsor-Quebec Corridor (WQC)						
- Windsor	15-20	146	115-125	40-53	155	72-93
- Toronto	25-30	164	115-125	44-52	117	56-66
- Stouffville	25-30	132	90-100	73-88	97	12-26
- Montreal	20-25	143	105-115	43-54	53	24-30
- Quebec	20-25	117	90-95	57-72	32	9-14
Southern Atlantic Region (SAR)						
- Saint John	10-30	93	65-85	55-100	13	0-6
- Kejimkujik	10-20	113	90-100	31-61	29	11-20

Overall, implementing both the base prevention program nationally and the illustrative remedial program in non-attainment areas would result in VOC reductions of 16% from the 1985 emission level. In total, VOCs of concern because of their toxicity rather than their reactivity in forming ozone should be reduced by roughly the same amount. The Phase I programs would result in a reduction in VOC emissions of 22% from solvent use, 57% from refineries, 45% from gasoline distribution systems and vehicle refueling, and 38% from organic chemical plants. The Plan will contribute a 16% reduction in VOCs from automobiles, which when added to the 37% reduction expected from current controls, will result in automobile emissions of VOCs 53% below current levels by 2005. As previously noted, studies in the United States have shown that most of the air toxics cancer risk in urban areas is due to emissions from road vehicles. Because most of the vehicle related control measures in the plan will be applied nationally, there will be significant reductions in exposures to potentially carcinogenic air pollutants in all Canadian urban areas.

From a human health perspective, indoor VOCs have been identified as an even greater concern than outdoor VOCs (NO_x/VOC Workgroup on Effects). Reductions identified in the Plan for various solvent use categories such as paints and coatings, glues and adhesives and personal care products should provide some reduction in indoor VOCs.

Overall, substantial benefits in terms of toxic VOC reductions should result from implementing the plan.

VIII.3 Effectiveness in Reducing Emissions of Greenhouse Gases

Control measures that increase energy consumption such as flue gas emission control devices that require energy to manufacture, install and operate, will increase CO_2 emissions. Those that involve combustion of VOC emissions such as incineration will put CO_2 into the atmosphere sooner, but will not significantly change the total loading of CO_2 to the atmosphere, since all VOCs eventually oxidize to CO_2 anyway. Measures such as electricity demand side management, equipment energy efficiency improvements, vapour recovery from gasoline marketing and distribution, reduction in solvent content of products and solvent recycle/reuse will all reduce CO_2 emissions.

CO_2 emission reductions from implementation of some of the Plan measures have been estimated by totalling the reductions from the various energy efficiency measures and deducting the energy penalties associated with operating NO_x and VOC emission control technologies in mobile source categories and industry (1-3% of pre-control CO_2 emissions, depending on the technology). The estimated net CO_2 reduction is 6.0% below the total projected CO_2 emissions in Canada in 2005. This excludes any credit for fuel savings from refinery and gasoline distribution vapour controls, from reduction in solvent VOC emissions through product control, process changes, and recycling and reuse, from improved energy conversion efficiencies that might result from the adoption of advanced combustion technologies such as Integrated Gasification Combined Cycle (IGCC), or from switching to lower carbon fuels in both mobile and stationary source categories that might be stimulated by the Plan.

VIII.4 Effectiveness in Meeting International Obligations

The international obligations of relevance to the plan are:

- basic obligations under the United Nations Economic Commission for Europe (ECE), International Convention on Transboundary Air Pollution

- a NO_x Protocol under the ECE Convention

- a pending VOC Protocol under the ECE Convention

- international commitments by Canada to take action to reduce CO_2 emissions and support development of an international convention on climate change.

The effectiveness of the Plan in meeting each of these obligations is described below.

Convention on Tranboundary Air Pollution.

This Convention, signed by Canada in 1979, obliges nations to prevent pollution produced within their confines from harming neighbouring states. It is interpreted by Canada in relation to NO_x and VOCs to mean that, as a minimum, there should be no increase in the transboundary flow of these pollutants from Canada into areas of the U.S. where NO_x and VOC related problems are already known to exist. To achieve this objective, Canada needs to ensure that no increase occurs in NO_x and VOC emissions in the Windsor - Quebec Corridor (WQC), the area from which most transboundary flow from Canada to the U.S. originates.

The interim emission reduction targets for the WQC, if based on the measures outlined in the Phase I Plan, will call for significant reductions in NO_x and VOCs in year 2000. This will decrease flows of NO_x, VOCs and O_3 into the U.S. The final 2005 emission caps for the WQC, which are to be set in the Phase II Plan in 1994, will require even greater reduction in NO_x and VOCs and consequently a further reduction in the transboundary flow of these pollutants from Canada to the U.S.

ECE NO_x Protocol

The NO_x Protocol, signed by Canada on October 31, 1988, calls for:

- a freeze in NO_x emissions at the 1987 level by December 31, 1994,

- national emission standards for major new mobile source categories and major new stationary sources and/or source categories based on "best available technology economically feasible",

- additional measures to reduce NO_x emissions from existing stationary sources taking into account age, utilization and other factors, and

- the commencement of international negotiations within 6 months after the protocol comes into force to establish measures and a time-table, by January 1, 1996, for further controls based on critical loads to the environment.

The Plan meets the first three provisions and, in being designed with the objective of resolving NO_x related environmental problems, will put Canada in a strong position for negotiating terms of the fourth provision with the United States. Regarding the primary provision of a freeze in NO_x emissions at the 1987 level, Canadian NO_x emissions as of the December 31, 1994 target date are projected to be about 3% below the 1987 level even without implementation of the Plan. The measures in the Phase I Plan will not provide any significant additional reductions by that date.

ECE VOC Protocol

This Protocol is currently under negotiation. The VOC control measures identified in the Phase I Plan and the projected total reduction in VOC emissions of 16% nationally by 2005 will provide guidance in developing the Canadian negotiating position regarding the protocol.

Commitment to Support Climate Change Control

Canada has led efforts to gain international agreement on measures to control global warming, including the hosting of an International Conference on Climate Change in 1988 which called for a 20% reduction in CO_2 emissions by 2005. A Canadian greenhouse gas control program is now being developed with a target of stabilization of CO_2 emissions at the 1990 level by year 2000.

Measures within the Plan to reduce energy consumption are consistent with the anticipated thrust of a major Canadian program for reducing emissions of greenhouse gases, and with Canadian support for an international convention on climate change. The estimated net reduction in projected CO_2 emissions in 2005 from implementing the Plan is about 6%. The net CO_2 reduction in year 2000 would be less, perhaps 3-5%. This is only a small part of the 25% reduction in projected 2000 emissions that would be needed to stabilize CO_2 emissions at the 1990 base year level. However, it is a first step and a solid demonstration of Canada's commitment to the control of climate change.

IX PLAN IMPLEMENTATION

IX.1 Schedule for Implementation of the Phase I Plan

Schedules for implementing the Phase 1 Plan initiatives are summarized in Tables 21, 22 and 23. Tables 21 and 22 provide the schedules for implementing the base prevention program initiatives for NO_x and VOCs respectively. They also outline the schedules that have been assumed for NO_x and VOC reduction initiatives in the illustrative regional remedial programs for ozone non-attainment areas. The schedule for the study initiatives of the Phase I Plan is contained in Table 23.

These schedules illustrate that a major effort will be required in the next few years to put all elements of the Plan in place. Some initiatives could be postponed to later years, but many, especially new source performance standards, are much less effective in reducing emissions in 2005 if implementation is delayed until the mid or late 1990s.

The argument for not delaying retrofit programs any longer than necessary is that they are the primary means of achieving short term improvements in air quality. When facilities are retrofitted, the results in terms of emission reductions are felt immediately. This is in contrast to new source requirements where a primary objective is the prevention of air quality deterioration, and any resulting improvements to existing air quality depend on the rate at which new facilities come to dominate the existing facility population.

IX.2 Provision for Environmentally Equivalent Programs

The Phase 1 Plan is structured with a starting menu or base set of NO_x and VOC control initiatives for the national prevention program, and an illustrative set of NO_x and VOC control initiatives for the regional remedial program. The province responsible in each regional setting, or non-attainment area, will select its own remedial program, drawing upon the illustrative remedial initiatives as appropriate.

Even though a base set of emission reduction initiatives has been established for the national prevention program, it is recognized that there may be alternative measures or schedules that could afford the same level of environmental protection within the same time frame as the measures and schedules specified. Any alternatives that responsible jurisdictions may wish to substitute for the base set of prevention initiatives should be identified to stakeholders (via the NO_x/VOC Consultations Office) along with an evaluation of their "environmental equivalency". Environmental equivalency is defined as equivalent or better ability to reduce ozone peaks and the duration of ozone exposure in the regions affected by the emission sources in question, and equivalent or better ability to provide the secondary environmental benefits of the base set of initiatives (e.g., reduction in ambient NO_2, nitrate deposition, toxic VOCs, CO_2, etc.). Alternative control proposals should in no way weaken the national preventive program either in its truly prevention component in which major emission sources and sectors expected to experience significant growth in emissions

TABLE 21 SCHEDULE FOR IMPLEMENTATION OF NO_x REDUCTION INITIATIVES IN THE PHASE I PLAN

Initiative		Control Instrument		
		Type	Delivery Date	Effective Date
(a) NATIONAL PREVENTION PROGRAM				
Energy Conservation and Product Control				
N101	Power utility DSM	DSM Plans	31 Dec. '92	2000-2005
N102	Energy efficiency in equipment, appliances	Performance Stds.	31 Dec. '94	1994
N103	Energy efficiency in industry	Performance Stds.	92/93/93/95	1993-1996
N104	Energy audits by industry	Audit Plans	31 Dec. '91	1992
N105	Energy efficiency in buildings	CSA Standards	31 Dec. '93	1994
Consumer Choice and Lifestyle				
N201	Public Education - Driving/Alt. Transport	Public Ed. Campaign	91-99	1991-1999
N202	Public Education - Energy Conservation	Public Ed. Campaign	91-99	1991-1999
Source Control				
N301	Light Duty Veh./Light Duty Truck NO_x limit	Federal Regulation	91-92	1994-1996
N302	Heavy duty vehicle NO_x limits	Voluntary/Fed. Reg.	91/93	1991/1994
N303	Const. diesel engine NO_x limits	Federal Regulation	31 Dec. '95	1998
N304	Cap on rail transport NO_x	Reporting Schedule	31 Dec. '91	1992
N305	NSPS - Power plants	CEPA Guideline	91-94	1995/2000
N306	NSPS - Industrial Boilers	CCME Guideline	31 Dec. '91	1994
N307	NSPS - Gas Turbines	CCME Guideline	30 June '92	1994
N308	NSPS - Compressor Engines	CCME Guideline	31 Dec. '91	1993
(b) ILLUSTRATIVE REGIONAL REMEDIAL PROGRAM (See Plan for Regional Application)				
Energy Conservation and Product Control				
N401	Urban Transportation Management	Management Plans	92-94	
Consumer Choice and Lifestyle				
N501	Ozone Episode Management	Mun. Plans/Criteria	31 Mar. '93	1993
N502	Highway speed reduction	Provincial Programs	31 Dec. '92	1993
N503	Public Education-Highway speeds	Prov. Pub. Ed. Campaign	92-99	1993-1999
Source Control				
N601	Motor Vehicle Inspection & Maintenance (I&M)	Provincial Programs	31 Dec. '93	1994
N602	New and Existing Power Plants	Prov. Limits/Schedules	31 Dec. '92	1994/1997
N603	Retrofit - Existing Industrial Boilers	Prov. Limits/Schedules	31 Dec. '93	1997
N604	New and Existing Iron & Steel Mills	Prov. Limits/Schedules	31 Dec. '93	1995/1997
N605	Retrofit - Existing Refinery Processes	CCME Guideline	31 Dec. '93	1997

TABLE 22 SCHEDULE FOR IMPLEMENTATION OF VOC REDUCTION INITIATIVES IN THE PHASE 1 PLAN

Initiative		Control Instrument		
		Type	Delivery Date	Effective Date
(a) NATIONAL PREVENTION PROGRAM				
Energy Conservation and Product Control				
V101	Emission Reduction - Surface Coating	CCME Reduction Plan	31 Dec. '93	1997
V102	Emission Reduction - Adhesives & Sealants	CCME Guideline	31 Dec. '93	1997
V103	Emission Reduction - Consumer Products	CCME Reduction Plan	30 June '94	1997
V104	Emission Reduction - General Solvent Use	CCME Reduction Plan	31 Dec. '94	2000
Consumer Choice and Lifestyle				
V201	Public Education - Driving/Alt. Transport	Public Ed. Campaign	91-99	1991-1999
V202	Public Education - Solvent Use/Recycle	Public Ed. Campaign	91-99	1991-1999
Source Control				
V301	Light Duty Veh./Light Duty Truck VOC Limit	Federal Regulation	91/92	1994-1996
V302	NSPS - Volatile Liquid Storage Tanks	CCME Guideline	31 Dec. '91	1993
V303	NSPS - Chemical Plant Processes	CCME Guideline	31 Dec. '92	1994
V304	NSPS - Chemical Plant Fugitive Emissions	CCME Code	31 Dec. '91	1993
V305	NSPS - Plastics Processing	CCME Guideline	30 June '93	1995
V306	NSPS - Pulp & Paper Sulphate Process	CCME Guideline	31 Dec. '92	1994
V307	NSPS - Comm/Ind. Coating Application	CCME Code/Guideline	31 Dec. '92	1994
V308	NSPS - Comm/Ind. Printing	CCME Code	30 June '93	1994
V309	NSPS - Comm/Ind. Degreasing	CCME Code	30 June '94	1995
V310	NSPS - Dry Cleaning	CCME Code	31 Dec. '93	1995
(b) ILLUSTRATIVE REGIONAL REMEDIAL PROGRAM (See Plan for Regional Application)				
Energy Conservation and Product Control				
V401	Urban Transportation Management	Management Plans	92/94	

TABLE 22 SCHEDULE FOR IMPLEMENTATION OF VOC REDUCTION INITIATIVES IN THE PHASE I PLAN (Count'd)

Initiative		Control Instrument		
		Type	Delivery Date	Effective Date
Consumer Choice and Lifestyle				
V501	Ozone Episode Management	Mun. Plans/Criteria	31 Mar. '93	1993
Source Control				
V601	Motor Vehicle Inspection and Maintenance (I&M)	Provincial Programs	31 Dec. '93	1994
V602	Gasoline Volatility Limit-62 KPa	Provincial Regulation	31 Dec. '91	1992
V603	Vapour Bal. - New & Exist. Gas. Depots	CCME Code	31 Dec. '90	1992/1993
V604	Vapour Bal. - New & Exist. Serv. Stations	CCME Code	31 Dec. '90	1992/1993
V605	Vehicle Refuel - Vapour Balance (Stage II)	CCME Code	31 Dec. '91	1993/1995
V606	Retrofit - Volatile Liquid Storage Tanks	CCME Guideline	31 Dec. '91	1994
V607	Fugitive Emission Control - Refineries	CCME Code/Prov. Sch.	31 Dec. '91	1993
V608	Retrofit - Chemical Plant Processes	Prov. Limits/Schedule	31 Dec. '92	1996
V609	Fugitive Emission Control - Chemical Plants	CCME Code/Prov. Sch.	31 Dec. '91	1993
V610	Retrofit - Existing Plastics Processing	Prov. Limits/Schedule	30 June '93	1996
V611	Retrofit - Existing Pulp & Paper Sulphate Proc.	Prov. Limits/Schedule	31 Dec. '93	1997
V612	Retrofit - Surface Coating Facilities	Prov. Limits/Schedule	31 Dec. '92	1996
V613	Retrofit - Existing Comm/Ind. Printing	Prov. Limits/Schedule	30 June '93	1996
V614	Retrofit - Existing Comm/Ind. Degreasing	Prov. Limits/Schedule	30 June '94	1997
V615	Retrofit - Existing Dry Cleaning	Prov. Limits/Schedule	31 Dec. '93	1997
V616	Retrofit - Existing Wood Waste Burning	Prov. Limits/Schedule	31 Dec. '92	1995

TABLE 23 SCHEDULE FOR IMPLEMENTATION OF STUDY INITIATIVES IN THE PHASE I PLAN

Study Initiative		Reference Agencies	Date
Emission Inventories and Forecasts (S100 Series)			
S101	Streamline Emission Inventories with Maximum 1 Year Lag Time.	Env. Canada All provinces	1993
S102	Update National Emission Forecast Annually, Extending to 2010.	Env. Canada All provinces	Annual
S103	Emission Surveys for the Pulp and Paper, Plastics processing and Wood Transformation Sectors.	Env. Canada, BC	31 Dec. '91
S104	More Accurate Data Base on Emissions From Products Containing Solvents	Env. Canada All provinces	31 Dec. '92
S105	Number and Usage Rates of Off-road Vehicles.	Env. Canada	31 Dec. '92
S106	Inventory Data for the WQC to Facilitate Oxidants Modelling.	Env. Canada Que, Ont	31 Dec. '91
Ambient Air Quality and Modelling (S200 Series)			
S201	Analysis of Available Ambient Air Monitoring Data.	Env. Canada NB, Ont, Que, BC	1991
S202	Expand the Ambient Air Monitoring Network for NO_x, VOC and Ozone.	Env. Canada All provinces	31 Dec. '93
S203	Better Information on the Transboundary Flow of NO_x, VOCs and Ozone.	Env. Canada NB, Ont, Que, BC	31 Dec. '91
S204	Refined Meteorological Data Sets to Facilitate Oxidants Modelling.	Env. Canada	30 June '91
S205	Set Up and Run Appropriate Scale Oxidants Models for the LFV and WQC.	Env. Canada Ont, Que, BC	1991/1993
S206	Evaluate Health Effects information and Develop Position on 6-8 hour Ozone Standard	H&W Canada All provinces	31 Dec. '92
S207	Evaluate Vegetation Effects and Develop Position on Appropriate Ozone Standard	Agric. Canada All provinces	31 Dec. '92

TABLE 23 SCHEDULE FOR IMPLEMENTATION OF STUDY INITIATIVES IN THE PHASE I PLAN (Cont'd)

Study Initiative		Reference Agencies	Delivery Date
Technologies, Control Options and Costs (S300 Series)			
S301	Refine Cost Estimates for VOC Emissions From Major Sources.	Env. Canada	31 Dec. '91
S302	Current VOC Emission Controls in Plastics, Pulp and Paper and Wood Transformation.	Env. Canada	31 Dec. '91
S303	R&D on Advanced Combustion and NO_x Emission Control Technologies.	Env. Canada EMR	1991-1995
S304	Current Control and Product Substitution in All Major Solvent Use Categories	Env. Canada All provinces	31 Dec.'91
S305	Control and Product Substitution Options for Major Solvent Use Categories.	Env. Canada All provinces	31 Dec. '91
S306	Implications of Greenhouse Gas Control Program for NO_x and VOC Emissions.	Env. Canada EMR, All provinces	Link to GHG Program
S307	Analyze Canadian Transportation Network to Determine Potential to Reduce NOx, VOC and CO_2 Emissions by Intermodal Shifts.	Transp. Canada EMR	31 Dec. '91
S308	Evaluate Energy Conservation Merits of Labelling and a Retrofit Building Code for Existing Buildings	EMR All provinces	31 Dec. '92
S309	Evaluate the Merits and Develop a Framework for NO_x/VOC Emission Trading	Env. Canada All provinces	31 Dec. '92
U.S. Emission Control (S400 Series)			
S401	Analyze New U.S. NO_x Control Program for NO_x Reductions in Selected Regions.	Env. Canada Ont, Que, BC	1991/1993
S402	Analyze U.S. State Implementation Plans (SIPs) in Selected Ozone Non-attainment Areas.	Env. Canada Ont, Que, BC	31 Dec. '92

in areas currently in attainment are dealt with, or in its contribution to the targetted emission reductions in non-attainment areas. In addition, they should not result in delays in achieving the emission reductions estimated for the base set initiatives.

The NO_x/VOC Consultation Office will distribute alternative plans and environmental equivalency evaluations that it has received to stakeholders for response. A summary of stakeholder response will be prepared by the office and provided to the NO_x/VOC Task Group of the CCME. Once finalized, the alternative plan will replace the Base Plan initiatives in question and the initiatives of the alternative plan will then be inserted in the NO_x/VOC Management Plan tracking system (see Section IX.5)

There may also, from time to time, be reasons for deleting from, modifying or adding to the study initiatives (S Series) of the Phase I Plan to account for new information or needs. Any proposed deviation from the studies identified should go through the same process of distribution to and review by stakeholders. Alternative study proposals should conform with the primary objective of these initiatives - to provide the essential information for development of Phase II of the Management Plan that will contain the final 2000 and 2005 NO_x and VOC emission caps for ozone non-attainment areas and the additional control measures needed to meet those caps. In considering alterations to the study initiatives it should also be born in mind that these initiatives are not intended to include all NO_x/VOC/O_3 work to be undertaken by all agencies over the next four years. It is assumed that agencies will have other internal study programs to deal with NO_x/VOC/O_3 that need not be defined as part of the Management Plan. For these reasons, it is recommended that caution be exercised in making any adjustments to the Phase I Plan study initiatives, and that any adjustments be fully rationalized against the objectives and be determined to be "essential" to the development of Phase II of the Plan.

This process of review and approval of alternatives to the base prevention and base study programs will ensure the continuing involvement of stakeholders as the Plan is implemented and will also ensure that the integrity of the Plan is maintained.

In regional settings, provinces may choose some alternative form of control program than one involving a set of regulatory actions for selected sectors emitting NO_x and VOCs, as portrayed in the illustrative remedial program. Possible alternatives include emission trading schemes in selected "ozone management regions". The overall control criteria will be the interim NO_x and VOC reduction targets for the ozone non-attainment areas. However, provinces will also want to look ahead to the final emission targets to be set in Phase II, since the final targets are expected to be in a more appropriate form for effective ozone management. The interim targets, due to emission information deficiencies, are expected to apply to annual emissions, while ozone episodes are daily or multi-day events in summer, and the areas to which they will apply are larger than the ideal size for ozone episode management. Because of these deficiencies in the interim targets, jurisdictions should as a minimum make some environmental equivalency comparisons in selecting the regional programs, whether they be regulatory in nature or emission trading schemes, even though no formalized environmental equivalency evaluation is proposed, for the remedial programs. A useful comparison might be whether they will ensure reductions in daily summertime emissions as great as reductions expected from the illustrative program, in approximately the same geographic locations, and within the same time frame. Even though emission reduction targets will be set for 1995 and 2000, some significant emission reductions would occur in advance of these dates if the scheduling in the illustrative remedial program were followed. For example, gasoline volatility reduction, Stage I vapour control on gasoline distribution, and motor vehicle inspection and maintenance would be expected well before 1995 under the illustrative program.

IX.3 Coordination

The Plan is complex and will require ongoing coordination to ensure its successful implementation. It is recommended this be achieved initially through a NO_x/VOC Consultation Office housed within Environment Canada but reporting to CCME. The office would operate on an interim basis for 1 year while CCME Environmental Protection Committee examines if and how the NO_x/VOC issue coordination should be integrated with the management of other atmospheric issues.

The responsibilities of the NO_x/VOC Consultation Office would include:

- assistance in developing federal/provincial agreements,

- coordination of stakeholder review of proposed alternatives to the Phase I Plan prevention or study initiatives,

- coordination of studies to further examine the feasibility of emission trading programs in general and for specified regional settings,

- coordination and delivery of the public education initiatives in the Phase I Plan (N201/V201, N202, V202),

- establishment of common formats for documents (codes, guidelines, etc.) to be prepared for each deliverable,

- assistance to lead agencies in the final packaging and submission of initiative documents to CCME,

- provision of regular updates on Plan implementation to stakeholders,

- acting as a focal point for inquiries (including media), and for the distribution of documents prepared for the Plan,

- preparation of briefing materials for CCME, and identifying key decisions required,

- management (probably through contract) of the operation of the Phase I Plan tracking system,

- development and implementation of a communications plan for the Plan,

- organization and management of the public consultation process for preparation of the Phase II of the Plan in 1994, and

- management of the general NO_x/VOC Management Plan budget on behalf of CCME

Initially, it is recommended that the NO_x/VOC Consultations Office consist of three persons with subsequent expansion to five if it is retained as a separate entity beyond the interim one year period. Two of the five persons would be assigned to implement the public education elements of the Plan and manage communications functions associated with the Plan.

The complete terms of reference and responsibilities of the NOx/VOC Consultations Office will be defined at the beginning of the Plan implementation.

IX.4 Mechanisms for Developing Specific Plan Initiatives

Almost all measures identified in the Plan require followup work, usually through a multi-stakeholder consultation process, to develop the actual control instrument or program to a stage where it can be implemented by the specified jurisdiction. This is true whether the measure is one of the base set of initiatives in the prevention program, a specific remedial measure, an emission trading program for ozone non-attainment areas, or a study initiative for development of the Phase II emission targets.

Coordination of the stakeholder consultation groups or task forces will be left to the lead agency identified for each task or program. Where the product is to be a control instrument identified in one of the prevention program initiatives, the lead agency will prepare a brief proposal on the process that will be used, the schedule and the intended final product for approval by the CCME Environmental Protection Committee. The lead agency will be responsible for progress reporting and, with the assistance of the NO_x/VOC Consultation Office, carrying the final product through to CCME approval and final publication.

The form of the consultation for regional remedial programs will depend on the nature of the control program selected. If the selected program is a set of specific control measures similar to that outlined in the illustrative remedial program in this Plan, then separate consultation groups would likely be set up to develop the specifics for each initiative similar to the process for the prevention program. On the other hand, if an emission trading scheme is selected, all sectors and interest groups may be represented in a single consultation forum.

The level of stakeholder consultation on many of the study initiatives will depend on the nature of the initiative and level of interest shown by stakeholders. Many of these initiatives are data gathering and technical evaluations and are not likely to generate widespread stakeholder interest.

IX.5 Evaluation and Reporting

The NO_x/VOC Consultation Office should develop a tracking system by which progress relative to the Phase I Plan schedules for all prevention and study initiatives, and progress towards the interim emission targets, can be easily monitored. A tracking system summary should be tabled at each meeting of the NO_x/VOC Task Group of CCME (or another CCME committee that may be assigned to oversee implementation of the Plan). The summary should also be readily available to all stakeholders at all times.

A brief annual progress report based on the tracking system, identifying problem areas (if any) and recommending corrective actions, should be prepared by the NO_x/VOC Consultation Office for approval by the NO_x/VOC Task Group and submitted to CCME in October of each year.

In the early years of the Phase I Plan implementation, there will be little that can be done to evaluate its effectiveness in improving air quality, since few of the measures will have been implemented long enough to establish any measurable trends. A simple tracking of emission reductions (using the streamlined inventory system recommended in the Plan) and of ambient ozone monitoring data will be maintained during the early years. As well, a standardized method of reporting emission and air quality trends will be developed, so that easy interpretation and year to year comparisons can be made. Summarized trend data will be included in the annual report to CCME. The report will also contain trend data for U.S. NO_x and VOC emissions in selected geographic regions, and observations on the effect of these trends on the transboundary flow of NO_x, VOCs and O_3 into Canada.

IX.6 Resources

Government and industry stakeholders are expected to cover their own costs for all task forces or work groups set up to develop specific control initiatives.

Also, governments and industry should set up equitable cost sharing arrangements to conduct the studies and investigations necessary to develop control initiatives, as well as the specific studies and investigations identified for preparing Phase II of the Plan in 1994.

It is recommended that CCME consider allocating an annual budget to fund participation of non-government organizations, public education and communications activities, editing and printing of control instruments and other plan related documents, and the travel and payroll of the NO_x/VOC Consultations Office.

X COST OF THE PHASE I PLAN

X.1 Development and Implementation Costs

Development and implementation costs include government and industry human resource and study costs, and costs of non-government organization participation. A typical regulatory initiative will take a minimum of 2 years, 4 person-years by the lead agency, person-year costs by 10 or more supporting government agencies, person-year costs for the participation of several industry and non-government organization representatives, plus allowances for some study and miscellaneous costs (travel, printing, etc.).

The cost of the Phase I Plan to governments is estimated at approximately $100 million over the 5-year period 1991-1995 inclusive. This cost is based on development and implementation of all the identified prevention program, illustrative remedial program and study initiatives identified in Chapter VI. The estimate includes funding support for non-government organization participation, the government share of study and investigation costs, the cost of maintaining a NO_x/VOC Consultation Office and the cost of developing the Phase II of the Plan in 1994. It is a global estimate and makes no allowance for existing government resources that would be applied to these emission sources or for control measure development costs that might be partially or totally covered under other government programs, such as federal and provincial greenhouse gas control programs.

Government costs may be different if emission trading schemes are implemented in regional settings. Neither the cost of putting such schemes in place nor the administrative burden required to track and control them have been well enough defined at this time to provide a reliable estimate of costs to governments.

X.2 Emission Control Costs

The costs of controlling NO_x and VOC emissions by implementing the base set prevention initiatives and the illustrative regional program initiatives are presented in Tables 24 and 25. The control costs have been estimated by multiplying the dollar per tonne removal costs times the number of tonnes of pollutant reduction in year 2005. The dollar per tonne numbers incorporate both capital repayment and operating and maintenance costs. All costs are very approximate at this stage and should be used as a rough "order of magnitude" estimate of the cost of the Plan to industry and other NO_x and VOC emitters.

The cost of the energy conservation and product control measures has been conservatively estimated as zero. Cost savings as high as $30,000/tonne may actually result from implementing some energy conservation measures. Product control measures will involve initial development and reformulation costs, but may not result in any significant cost differences

TABLE 24 COST OF ACHIEVING NO_x EMISSION REDUCTIONS

Initiative	Year 2005 Emission Reduction (T)	Reduction Cost (1989 \$/T)	Year 2005 Annual Cost (1989 \$X10^6)
(a) National Prevention Program			
N101 Electric Utility DSM	\		
N102 Energy Efficiency Stds	/ 38,500	0	0
N103 En. Eff. Perf. Stds-Ind.	20,700	0	0
N104 Energy Audits-Industry	N.E.	N.E.	N.E.
N105 En. Eff. Perf. Stds-Bldgs.	3,700	0	0
N201 Public Ed-Driving/Alt. Trans.	N.E.	N.E.	N.E.
N202 Public Ed-Energy Cons.	N.E.	N.E.	N.E.
N301 LDV/LDT NO_x Limit	64,000	2,300	147.2
N302 HDV NO_x Limit	20,900	N.E.	N.E.
N303 Const. Diesel NO_x Limit	7,900	N.E.	N.E.
N304 Rail NO_x Cap	-	-	-
N305 NSPS Power Plants	25,400	300	7.6
N306 NSPS Comm/Ind Boilers	35,900	500	18.0
N307 NSPS Turbines	6,300	500	3.2
N308 NSPS Recip. Engines	3,000	3,500	10.5
(b) Illustrative Regional Remedial Program			
N401 Urban Transportation Mgt.	N.E.	N.E.	N.E.
N501 Ozone Episode Management	N.E.	N.E.	N.E.
N502 Speed Reduction-HDVs	5,100	1,000	5.1
N503 Speed Reduction Pub. Ed.	N.E.	N.E.	N.E.
N601 LDV Inspect & Maintain.	5,100	3,000	15.3
N602 Retrofit Power Plants	58,000	3,000	174.0
N603 Retrofit C/I Boilers	3,100	1,000	3.1
N604 New and Exist. Iron & Steel Proc.	3,200	3,000	9.6
N605 Retrofit Refinery Processes	7,200	3,000	21.6
	308,000	1,348 (Avg.)	415.1

N.E. denotes "no estimate" at this time.

TABLE 25 COST OF ACHIEVING VOC EMISSION REDUCTIONS

Initiative	Year 2005 Emission Reduction (T)	Reduction Cost (1989 \$/T)	Year 2005 Annual Cost (1989 \$X10^6)
(a) National Prevention Program			
V101 Surface Coating	13,400	0	0
V102 Adhesives and Sealants	14,000	0	0
V103 Consumer Products	9,000	0	0
V104 General Solvent Use	27,000	1,000	27.0
V201 Public Ed. - Driving/Alt. Trans.	N.E.	N.E.	N.E.
V202 Public Ed. - Solvent Use	N.E.	N.E.	N.E.
V301 LDV/LDT VOC Limit	16,300	2,300	37.5
V302 NSPS - Vol. Liquid Tanks	8,800	300	2.6
V303 NSPS - Org. Chem. Plants Proc.	4,900	400	2.0
V304 NSPS - Org. Chem plants Fug.	3,900	1,700	6.6
V305 NSPS - Plastic Processing	5,200	400	2.1
V306 NSPS - Pulp & Paper	5,200	1,500	7.8
V307 NSPS - Coating Application	45,200	1,200	54.2
V308 NSPS - Printing	5,900	1,200	7.1
V309 NSPS - Degreasing	4,600	100	0.5
V310 NSPS - Dry Cleaning	2,900	900	2.6
(b) Illustrative Regional Remedial Program			
V401 Urban Trans. Mgt.	N.E.	N.E.	N.E.
V501 Ozone Episode Management	N.E.	N.E.	N.E.
V601 LDV/LDT Inspect & Maintain	30,700	3,000	92.1
V602 Gasoline Volatility Reduction	49,000	1,000	49.0
V603 Stage I - Depot (N&R)	14,300	100	1.4
V604 Stage I - Serv. Sta. (N&R)	14,500	200	2.9
V605 Stage II - Serv. Sta. (N&R)	21,000	3,000	63.0
V606 Retrofit Vol. Liq. Tanks	8,900	400	3.6
V607 Fug. Em - Refineries	15,800	400	6.3
V608 Retrofit - Org. Chem. Proc.	5,400	600	3.2
V609 Retrofit - Org. Chem. Fug. Em.	3,000	400	1.2
V610 Retrofit - Plastic Processing	4,200	600	2.5
V611 Retrofit - Pulp & Paper	1,000	2,000	2.0
V612 Retrofit Coating Application	38,500	1,200	46.2
V613 Retrofit - Printers	6,000	1,200	7.2
V614 Retrofit - Degreasing	3,700	200	0.7
V615 Retrofit - Dry Cleaning	1,500	1,200	1.8
V616 Retrofit - Wood Waste Comb.	4,000	2,000	8.0
	387,800	1,100 (Avg.)	441.2

N.E. denotes "no estimate" at this time.

N&R means "new and retrofit"

The distribution of emission reductions and control costs among provinces is estimated as follows:

	NO_x (2005)		VOCs (2005)		Total Cost ($\$x10^6$)	% of Total Cost
	Red(KT)	Cost($\$x10^6$)	Red(KT)	Cost($\$x10^6$)		
B.C.	25.6	34.3	44.7	57.9	92.2	10.8
Alta.	53.5	22.5	15.1	13.5	36.0	4.2
Sask.	19.8	15.3	4.7	4.5	19.8	2.3
Man.	7.2	7.6	4.7	4.6	12.2	1.4
Ont.	138.2	282.9	214.3	248.9	531.8	62.1
Que.	33.3	38.6	87.6	97.2	135.8	15.8
N.B.	15.7	5.6	6.7	6.0	11.6	1.4
N.S.	8.6	4.7	6.5	5.9	10.6	1.2
P.E.I.	0.5	0.7	0.7	0.7	1.4	0.2
NFLD.	3.7	2.6	2.4	2.0	4.6	0.5
Y/NWT.	1.9	0.5	0.3	0.2	0.7	0.1
	308.0	415.1	387.8	441.2	856.3	100.0

Overall the costs are split among sectors/kind of initiative as follows:

	B.C.	Ont.	Que.	Other	Nat.	% of Total
Energy Conservation	0.0	0.0	0.0	0.0	0.0	0.0
Product Control	0.0	0.0	0.0	0.0	0.0	0.0
Mobile Sources (Incl. RVP, Stage I, II)	52.9	223.0	83.6	53.8	413.4	48.2
Stationary Sources						
NSPS - Paints/Coatings	5.4	27.2	13.4	8.2	54.2	6.3
- Power	0.0	0.0	0.0	7.6	7.6	0.9
- Other	13.8	34.6	15.9	25.6	89.9	10.5
Retrofit - Paints/Coat	3.8	28.2	13.9	0.3	46.2	5.4
- Power	2.4	171.6	0.0	0.0	174.0	20.4
- Other	13.9	47.2	9.0	1.0	71.1	8.3
Total Stationary	39.3	308.8	52.2	42.7	443.0	51.8
TOTAL	92.2	531.8	135.8	96.5	856.3	100.0

The above table indicates that 81.2% of the costs are split between 3 source categories:

Mobile (mainly LDV/LDT)	48.2%
Power Generation	21.3%
Paints/coatings	11.7%
	81.2%

The remaining 18.8% ($161.0 m/yr) is split between numerous stationary source categories the largest being:

Refineries	3.3%
Gen. Solvent Use	3.2%
Comm/Ind. Boilers	2.5%
Printing	1.7%
Org. Chem. Plants	1.5%

compared to existing products over the long term. More information is needed to refine the estimates for energy conservation and product control initiatives. In the interim they are listed as cost neutral.

Overall the annual cost to NO_x/VOC emitters in 2005 of the Phase I control initiatives is estimated at $856.3 million (1989 $), split between NO_x and VOC control initiatives as follows:

NO_x Control Initiatives	$ 415.1 million
VOC Control Initiatives	441.2
	$ 856.3

Approximately 67% of the mobile source costs are due to new motor vehicle emission standards (national) and inspection and maintenance programs (regional). These would be incurred directly by purchasers and operators of motor vehicles. The remaining 33% of mobile source costs derive from measures to reduce gasoline volatility, and from emission reduction programs for gasoline distribution and vehicle refuelling.

The cost of reducing VOC emissions from the application of paints and coatings would be incurred primarily in commercial and industrial painting operations, such as the painting required in automobile and equipment manufacturing. No estimate has been made of what effect this would have on the price of the wide variety of products involved.

Costs of controlling NO_x from power generation would be passed on to consumers in increased electricity rates. Most of the power industry costs would be incurred in Ontario, from retrofitting NO_x controls on existing power plants. These would translate into an increase in the average electricity rate in Ontario of about 2%. Based on economic studies done on commodity price changes due to increased electricity rates resulting from SO_2 controls at Canadian power plants (Melvin 1980), an electricity rate increase of 2% should not result in commodity price increases of more than 0.1% in any commodity category. The referenced economic studies covered 103 commodities and 43 industrial sectors. To residential consumers, a 2% rate increase represents $10 per year per household based on an average household electricity bill of $500 per year.

The remaining $161 million per year costs are split among many NO_x and VOC sources and would be distributed across hundreds of different commodity types. They translates into about $6 per person per year, or less than 2 cents per person per day.

Expressed on a per capita basis, the total cost of the Phase I Plan, $856.4 million per year in 2005, is about $34 per person per year, or 9 cents per person per day.

XI PHASE II OF THE PLAN

Phase II of the Plan will contain final 2000 and 2005 emission targets for ozone non-attainment areas, and the additional measures needed to meet those targets. The final 2005 targets will be selected to ensure consistent attainment of the maximum acceptable ozone objective of 82 ppb in all areas of the country by 2005. Phase II may include the designation of, and setting of targets for, additional ozone non-attainment areas to the three areas designated in Phase I. These would likely be airsheds around some of the larger urban centres where occasional exceedances of the ozone objective occur, or are expected to occur, even after implementing the Phase I Plan.

It is unlikely that Phase II would be limited only to additional remedial measures in ozone problem areas. Additional or more stringent national prevention measures can be expected to play a role in reaching the final emission caps to be established in the Phase II Plan.

The Phase II Plan will account for factors that are likely to change in the next few years. Some of these factors are:

- new emission forecasts projecting higher or lower emissions in future years than assumed in Forecast 90-A,
- new technological innovations expanding opportunities to reduce emissions and providing better cost effectiveness,
- the identification of new concerns for the health and/or environmental effects of NO_x, VOCs and O_3,
- new initiatives by the United States to control NO_x and VOC emissions, and Canadian negotiating positions for including NO_x, VOCs and O_3 in a Transboundary Air Quality Agreement,
- negotiations with the United States on further control measures for NO_x based on critical loads to the environment as per conditions of the ECE NO_x Protocol,
- final conditions of the ECE VOC Protocol now under negotiation,
- new information on source/receptor relationships obtained from oxidants modelling,
- better information on emission sources and control options for some sectors,
- better information on the feasibility of using emission trading for ground-level ozone management, and
- the effect on NOx and VOC emissions of programs to control greenhouse gases.

Consultations with stakeholders will begin in the latter half of 1993 on the preparation of Phase II of the NO_x/VOC Management Plan, with a target date for completion of October, 1994.

REFERENCES

Altshuller, A.P., Estimation of the Natural Background of Ozone Present at Surface Rural Locations, Journal of Air Pollution Control Association, December, 1987.

Altshuller, A.P., The Role of Nitrogen Oxides in Nonurban Ozone Formation in the Planetary Boundary Layer over North America, W. Europe and Adjacent Areas of Ocean, Atmospheric Environment Vol. 20, No. 2, 1986.

Altshuller, A.P., Review: Natural Volatile Organic Substances and Their Effect on Air Quality in the United States, Atmospheric Environment Vol. 17, No. 11, 1983.

Angle, R.P. and Sandhu, H.S., Rural Ozone Concentrations in Alberta, Canada, Atmospheric Environment Vol. 20, No. 6, 1986.

ASMAC, Brief on the Draft Management Plan for NOx and VOCs, April 27, 1990.

Bates, D.V., Human Response to Air Pollutants, September, 1989.

Bennett, R.C., NO_x-VOC Management Plan - Technical Comments, April 12, 1990.

Burkhart, R.P., A Trajectory Analysis of Ozone Exceedances in Coastal Maine, Air and Waste Management Association, June, 1990.

California Air Resources Board, ARB Staff Proposal for Hydrocarbon Reactivity Adjustment Factors for Clean Fuel/Low Emission Vehicle Regulations, Discussion document for ARB Staff Consultation Meeting, February 21, 1990.

Cantrell, B., Ludwig, F.L. and Singh, H.B., A Review of the Fate of NO_x and its Role in Rural Ozone Formation, SRI report prepared for U.S. EPA, August, 1983.

CCPA, The Canadian Chemical Producers Association Comments on the Draft CCME Management Plan for Nitrogen Oxides and Volatile Organic Compounds, April 30, 1990.

Coligado M.C. (1988) Air Parcel Trajectories during Ozone Episodes in the Lower Fraser Valley, Proceedings of the 1988 Annual Meeting, Pacific-West International Section, Air and Waste Management Association, Whistler, B.C., Nov. 9-11.

Communaute Urbaine de Montreal, Bylaw 90, 1987.

Concord Scientific Corp. and B.H. Levelton & Associates, GVRD Air Management Plan-Stage 1: Assessment of Current and Future Air Quality, prepared for Greater Vancouver Regional District, Pollution Control Division, September, 1989.

CCPI, Canadian Petroleum Products Institute Comments on the Draft CCME Management Plan for Nitrogen Oxides and Volatile Organic Compounds, April 18, 1990.

Dann, T., Speciation and Reactivity of Volatile Organic Compounds in Ambient Air Samples and Emission Inventories, Pollution Measurement Division, Conservation and Protection, Environment Canada, November, 1989.

Dann, T., Trends in Ambient Ozone Concentrations in Canada, 1979-1986, Air Pollution Control Association, June, 1988.

Dann, T., Wang, D., and Etlinger, A., Volatile Organic Compounds in Canadian Ambient Air: A New Emphasis, Pollution Measurement Division, Environment Canada and Etlinger Environmental, September, 1989.

Davis, C.S., Moran, M.D., Portelli, R.V., Reid, N.W., Bates, D.V. and Scheer, D.B., Final Report: Initial Assessment Report on Photochemical Oxidant Air Pollutants in Canada, Concord Scientific Corporation and University of British Columbia Department of Health Care and Epidemiology, April, 1984.

Derwent, R.G. and Jenkin, M.E., Hydrocarbon Involvement in Photochemical Ozone Formation in Europe, Environmental and Medical Sciences Division, Harwell Laboratory, Oxfordshire, England, May, 1990.

Dimitriades, B., Photochemical Oxidant Formation: Overview of Current Knowledge and Emerging Issues, U.S. Environmental Protection Agency, Office of Research and Development, EPA/600/D-88/064, April, 1988.

Edwards, W.C., Quan, R.G., Lee, N.P., Emissions of Volatile Organic Compounds From Selected Chemical Plants, Draft Report, B.H. Levelton & Associates Ltd, Vancouver, B.C., May 1990.

Fay,J.A., Golomb, D. and Zemba, S.G., A Regional Model of Annual Average Airborne NO_x, Energy Laboratory, Massachusetts Institute of Technology, Transactions - APCA International Speciality Conference, Ozone Control Strategies: The Scientific and Technical Issues Facing Post - 1987, November, 1987.

Federal Republic of Germany and the Netherlands, PHOXA Photochemical Oxidant and Acid Deposition Model Application Within the Framework of Control Strategy Development, Summary Report, July, 1989.

Finlayson-Pitts, B.J. and Pitts, J.N., Atmospheric Chemistry: Fundamentals and Experimental Techniques, California State University and University of California, 1986.

Friedman, R.M., Milford, J., Rapoport, R., Szabo, N., Harrison, K. and Aller, S.V., Urban Ozone and the Clean Air Act: Problems and Proposals for Change, Staff Paper - Office of Tehcnology Assessment, United States Congress, April, 1988.

Jensen, K.F., Summary and Evaluation of Research on Native Vegetation, U.S. Dept. of Agriculture, November 1984.

Lahre, T., Cancer Risks from Air Toxics in Urban Areas, Air Pollution Control Association, June, 1988.

Lamb, R.G., Diagnostic Studies of Ozone in the Northeastern United States Based on Applications of the Regional Oxidant Model (ROM), Atmospheric Science Research Laboratory, U.S. Environmental Protection Agency, Transactions - APCA International Speciality Conference, Ozone Control Strategies: The Scientific and Technical Issues Facing Post - 1987, November, 1987.

Lefohn, A.S. and Benkovitz, C.M., Air Quality Measurements and Characteristics for Effects Research, A.S.L. & Associates, prepared for National Acid Precipitation Assessment Program, U.S. Department of Energy, December, 1989.

Legge, A.H., The Present and Potential Effects of Acidic and Acidifying Air Pollutants on Alberta's Environment, Critical Point 1 Summary Report, The Acid Deposition Research Program, Biophysical Research, September, 1988.

Lippmann, M., Health Effects of Ozone, A Critical Review, Institute of Environmental Medicine, New York University Medical Center, Journal of Air and Waste Management Association, 1989.

McKee, D.J., Health Effects of Ozone and Nitrogen Oxides, Northeast States for Coordinated Air Use Management (NESCAUM) Symposium on The Role and Importance of Nitrogen Oxide Emissions Controls in Ozone Attainment Strategies for Eastern North America, May, 1990.

McKee, D.J. and Johnson, P.M., Critical Issues in the Review of the Ozone National Ambient Air Quality Standards, U.S. Environmental Protection Agency, Research Triangle Park, 81st Annual Meeting of APCA, June 19-24, 1988.

Melvin, J.R., The Economic Effects of Increases in Electrical Power Prices Associated with Pollution Control for Canadian Thermal Power Plants, Department of Economics, University of Western Ontario, prepared for Environment Canada, August, 1980.

National Energy Board (NEB), Canadian Energy Supply and Demand 1987-2005, September, 1988.

NO_x/VOC Work Group on Modelling, January 1990
NO_x/VOC Work Group on Effects, January 1990
NO_x/VOC Work Group on Principles of Apportionment, January, 1990
NO_x/VOC Work Group on Public Education, January 1990
NO_x/VOC Work Group on Energy Efficiency/Alternative Energy/Lifestyle, January 1990
NO_x/VOC Work Group on Control Technologies, January 1990
NO_x/VOC Work Group on Emission Inventories, January 1990

Northeast States for Coordinated Air Use Management (NESCAUM), NESCAUM Stationary Source Committee Recommendation on Emission Limits for Gas Turbines, October, 1988.

Ozkaynak, H. and Burbank, B., Review of Epidemiological Studies on Ozone Exposures, Harvard University, 81st Annual Meeting of APCA, June 19-24, 1988.

Pearson, R.G. and Donnan, J.A., Impact of Ozone Exposure on Vegetation in Ontario, Ontario Ministry of the Environment, 1989.

Pierson, W.R., Gertler, A.W. and Bradlow, R.L., Camparison of SCAQS Tunnel Study with Historical Data, Air and Waste Management Association, June, 1990.

Porter Dillon Limited, New Brunswick - Nova Scotia Oxidants Study Update, Draft Report, prepared for Environment Canada, Conservation and Protection, Atlantic Region, March, 1988.

Posseil, N.C., Doll, D.C., Baugues, K.A., Baldridge, E.W. and Wayland, R.A., Impacts of Regional Control Strategies on Ozone in the Northeastern United States, Air and Waste Management Association, June, 1990.

Pratapas, J.M. and Caccagni, J., Env. Intal., 9, 1983, 529.

Seinfeld, J.H., Ozone Air Quality Models, A Critical Review, Department of Chemical Engineering, California Institute of Technology, Journal of Air Pollution Control Association, 1988.

Scheffe, R.D. and Morris, R.E., Assessment of Ozone Precursor Control Measures Using the Urban Airshed Model in EPA's 5-City UAM Study, Air and Waste Management Association, June , 1990.

Shane, B.S., Human Reproductuve Hazards, Evaluation and Chemical Etiology, Louisianna State University, American Chemical Society, 1989.

Sillman, S., Jacob, D.J., Logan, J.A., Spivakousky, C.M., Yevich, R.M. and Wofsy, S.C., Theoretical Studies of Long Range Transport of Oxidants, Final Report, Department of Earth and Planetary Sciences and Division of Applied Sciences, Harvard University, December 29, 1987.

South Coast Air Quality Management District (SCAQMD) and Southern California Association of Governments (SCAG), Air Quality Management Plan, South Coast Basin, March, 1989.

Taylor, G.E. Jr and Norby, R.J., The Significance of Elevated Levels of Ozone on Natural Ecosystems in North America, Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, Tenn., November 1984.

U.S. Department of Energy (DOE), NO_x Information Book, DOE/NBB-0044, March, 1983.

U.S. Environmental Protection Agency (EPA), Numerical Simulations of Photochemical Air Pollution in the Northeastern United States- ROM1 (Regional Oxidants Model) Applications, July 1986.

U.S. Environmental Protection Agency, Summary of Selected New Information on Effects of Ozone on Health and Vegetation: Draft Supplement to Air Quality Criteria for Ozone and Other Photochemical Oxidants, EPA Office of Health and Environmental Assessment, November, 1988.

Wilson, J.H., Laich, E.J. and Bunyard, F.L., Ozone Nonattainment - An Analysis of Proposed Legislation, Air and Waste Management Association, June, 1990.

Zierock, K.H., Photochemical Oxidants: Summary of Studies Relevant to an Abatement Policy, Envi Con Environmental Consultancy, prepared for Commission of the European Communities Report on Environment and Quality of Life, 1988.

APPENDIX A

NO_x/VOC EMISSION FORECAST 90-B

NO_x/VOC Emission Forecast 90-B

NO_x/VOC Emission Forecast 90-B is the base forecast for the November, 1990 Management Plan for Nitrogen Oxides (NO_x) and Volatile Organic Compounds (VOCs).

Forecast 90-B contains the following changes from Forecast 90-A, which was the reference forecast for the March, 1990 Draft Management Plan.

(a) NO_x Emissions

- Forecasted NO_x emissions for the natural gas industry in Alberta have been increased substantially to account for a higher projected growth in the industry and a smaller anticipated NO_x reduction from the 1988 Alberta compressor engine design requirements:

NO_x Emissions from Natural Gas Industry - Alberta

	1985	2005
Forecast 90-A	131.5 KT	76.7 KT
Forecast 90-B	131.5 KT	169.4 KT

- There is a minor increase in the Quebec power generation NO_x emission estimate for 1990 (from 1.9 to 3.8 KT) to reflect increased current usage of the Tracy oil-fired generating station.

(b) VOC Emissions

- Both the base year (1985) and the forecasted emission rates for the petrochemical industry have decreased substantially to better reflect the current level of emission control within the industry and anticipated control on new facilities in the future:

VOC Emissions from Petrochemical Industry-National

	1985	2005
Forecast 90-A	107.8 KT	206.8 KT
Forecast 90-B	36.4 KT	51.3 KT

The above natioanl changes result from adjusted forecasts for petrochemical plants in Quebec, Ontario, Alberta and British Columbia.

NO_x Emission Projections - Assumptions

A. Base Year: 1985

Sources of Data (base year):

- Motor vehicles - population - Statistics Canada
  - Transportation Systems Division (TSD), Env. Canada
  - emission factors - TSD
    - new MOBILE4 data
  - vehicle miles travelled - TSD

- other transportation - fuel consumption - Statistics Canada
  - emission factors - U.S. EPA (AP-42)
    - Railway Assoc. of Canada (RAC)

- fuel combustion - fuel consumption - Statistics Canada
  - emission factors - U.S. EPA
  - petroleum refineries:
    - emissions - provided by refineries and provinces
    - fuel consumption - supplied by refineries and provinces
    - emissions factors - U.S. EPA
  - natural gas processing:
    - emissions obtained directly from provincial agencies (also: fuel consumption)

- power generation - emissions generally supplied by provincial utilities & power commissions (also includes fuel consumption)

  - additional emissions from small stations and gas turbines calculated from fuel consumption data and U.S. EPA emission factors

- industrial processes:
  - emissions data from 1985 inventory
  - data generated either through provincial agencies (point sources) or statistics Canada production figures

- incineration/miscellaneous:
  - emissions calculated by use of Statistics Canada data with emission factors

B. Forecast Years: 1986-2005

Sources of Data:

- motor vehicles
  - emission factors - TSD
  - growth in car/truck stock by fuel type
  - National Energy Board (NEB) transportation model
  - Motor Vehicle Manufacturers Association (MVMA) sales forecasts
  - assumes no change in vehicle miles travelled

- other transportation
  - growth in energy consumption (e.g., 1987 vs. 1985 values) - NEB
  - province-specific statistics
  - assumes no change in emission factors or level of control technology available
  - Railway Association of Canada projections of fuel demand and emissions in the rail sector

- fuel combustion
    - industrial/commercial/residential
        - growth in energy consumption (for each fuel) - NEB
    - province-specific statistics
    - assumes no change in emission factors or level of control

Technology Available

- petroleum refineries (fuel combustion)
    - growth in energy demand (petroleum products) - NEB
    - assumes no changes in emission factors or level of control technology

- natural gas processing (fuel combustion)
    - Informetrica GDP growth rates for "Petroleum & gas-resource extraction" except in Alberta where the Energy Resource Conservation Board energy demand and emissions forecasts are used.
    - Alberta forecast assumes about an 8% reduction in year 2005 emissions as a result of the Alberta 1988 design requirements for compressor engines

- power generation
    - emissions forecasts obtained from various provincial utilities and from Oil, Gas & Energy Division, Env. Canada simulation model (CANSIM)

- Industrial processes
    - Informetrica GDP growth rates used for following sectors:
      Nitric acid - "Chemicals" sector
      Nitrate fertilizer - "Chemicals" sector
      Metallurgical coke - "Petroleum & coal products manufacturing" sector
      Aluminum production - "Primary metals" sector
      Sulphate pulping - "Pulp & paper" sector
      Tar sands - "Mining services" sector

    - data for growth rates are province-specific
    - petroleum refineries, growth in energy demand (petroleum products) - NEB

- incineration/miscellaneous
    - population growth rates for growth in incineration practices
    - wigwam burners - Informetrica GDP growth rates for the "Wood manufacturing" sector
    - slash burning - Informetrica GDP growth rates for the "Forestry" sector

Note: All growth rates are for a "high growth" scenario as forecast by the NEB (1988). Informetrica growth rates are based on the most recent tabulations from their economic model.

NITROGEN OXIDE (NO_x)

CANADA

KILOTONNES (as NO_2)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	352.0	250.4	169.0	145.4	149.8
Light-Duty Trucks					
Gas	95.4	86.4	78.7	74.9	77.5
Diesel	5.7	6.9	6.9	8.7	10.9
Heavy-Duty Trucks					
Gas	20.9	13.5	8.0	6.3	6.8
Diesel	264.3	322.0	241.2	230.3	254.0
Off-Road Diesel					
Construction	31.3	32.0	36.0	41.7	49.4
Agriculture	53.5	64.8	70.2	74.8	81.0
Railroads	132.1	113.2	114.0	113.0	113.0
Other	145.6	149.7	168.0	180.1	187.0
Other	79.4	82.7	84.0	86.2	90.6
Fuel Combustion					
Residential	41.5	37.3	37.2	37.2	36.9
Commercial	25.8	25.9	27.3	27.8	28.4
Industrial					
Natural Gas	158.8	199.8	220.5	222.9	205.2
Other	119.4	131.8	150.5	163.7	178.9
Power Generation	247.9	289.6	319.2	363.9	351.7
Industrial Processes	89.0	89.9	104.0	119.8	139.7
Incineration/Miscellaneous	24.3	27.2	29.2	31.9	34.6
TOTAL	1886.9	1923.1	1863.9	1928.6	1995.4

PROVINCE: Newfoundland

KILOTONNES (as NO_2)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	4.9	3.1	1.9	1.7	1.8
Light-Duty Trucks					
Gas	2.1	1.8	1.6	1.5	1.6
Diesel	0.1	0.1	0.1	0.2	0.2
Heavy-Duty Trucks					
Gas	0.7	0.4	0.2	0.1	0.1
Diesel	5.6	7.9	6.6	6.5	7.1
Off-Road Diesel					
Construction	0.4	0.2	0.4	0.4	0.4
Agriculture	0.1	0.1	0.1	0.1	0.2
Railroads	0.8	-	-	-	-
Other	5.8	6.0	6.9	7.7	8.2
Other	2.6	3.0	3.0	3.1	3.2
Fuel Combustion					
Residential	0.8	0.8	0.8	0.8	0.8
Commercial	0.4	0.4	0.3	0.3	0.3
Industrial					
Natural Gas	-	-	-	-	-
Other	2.4	3.2	3.3	3.7	4.3
Power Generation	5.3	6.0	5.6	5.8	5.8
Industrial Processes	1.3	1.3	1.6	1.7	1.7
Incineration/Miscellaneous	0.4	0.4	0.5	0.5	0.5
TOTAL	33.7	34.7	32.9	34.1	36.2

PROVINCE: Prince Edward Island

KILOTONNES (as NO_2)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	1.6	1.0	0.6	0.6	0.6
Light-Duty Trucks					
Gas	0.5	0.5	0.4	0.4	0.4
Diesel	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Heavy-Duty Trucks					
Gas	0.2	0.1	0.1	< 0.1	< 0.1
Diesel	1.5	2.1	1.8	1.7	1.9
Off-Road Diesel					
Construction	0.1	0.1	0.2	0.2	0.2
Agriculture	0.3	0.4	0.5	0.6	0.6
Railroads	0.1	0.2	0.1	0.1	0.1
Other	0.3	0.3	0.4	0.4	0.4
Other	0.3	0.3	0.3	0.3	0.3
Fuel Combustion					
Residential	0.4	0.4	0.4	0.4	0.4
Commercial	0.1	0.1	0.1	0.1	0.1
Industrial					
Natural Gas	-	-	-	-	-
Other	< 0.1	< 0.1	< 0.1	< 0.1	0.1
Power Generation	0.1	0.1	0.1	0.1	0.1
Industrial Processes	-	-	-	-	-
Incineration/Miscellaneous	0.1	0.1	0.1	0.1	0.1
TOTAL	5.6	5.7	5.1	5.0	5.4

PROVINCE: Nova Scotia

KILOTONNES (as NO_2)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	10.6	6.8	4.2	3.7	3.9
Light-Duty Trucks					
Gas	4.0	3.4	3.1	2.9	3.0
Diesel	0.2	0.3	0.3	0.3	0.4
Heavy-Duty Trucks					
Gas	1.1	0.6	0.3	0.2	0.2
Diesel	12.8	18.2	15.2	14.9	16.4
Off-Road Diesel					
Construction	0.7	0.6	0.6	0.7	0.8
Agriculture	0.7	1.0	1.2	1.4	1.6
Railroads	4.1	5.2	5.2	5.2	5.2
Other	8.3	8.4	9.8	10.9	11.6
Other	2.1	2.4	2.5	2.5	2.6
Fuel Combustion					
Residential	1.8	1.8	1.7	1.6	1.6
Commercial	1.2	1.0	0.9	0.9	0.8
Industrial					
Natural Gas	-	-	-	-	-
Other	2.9	3.4	3.6	4.0	4.6
Power Generation	21.7	25.2	26.7	26.8	27.1
Industrial Processes	1.6	1.7	1.8	2.0	2.1
Incineration/Miscellaneous	0.5	0.7	0.7	0.8	0.9
TOTAL	74.3	80.7	77.8	78.8	82.8

PROVINCE: New Brunswick

KILOTONNES (as NO_2)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	8.3	5.3	3.3	2.9	3.0
Light-Duty Trucks					
Gas	3.3	2.8	2.5	2.4	2.4
Diesel	0.2	0.2	0.2	0.3	0.3
Heavy-Duty Trucks					
Gas	0.9	0.5	0.2	0.2	0.1
Diesel	8.8	12.5	10.4	10.3	11.3
Off-Road Diesel					
Construction	0.5	0.6	0.6	0.6	0.7
Agriculture	0.5	0.7	0.9	1.0	1.2
Railroads	2.4	3.1	3.1	3.1	3.1
Other	3.5	3.6	4.1	4.6	4.9
Other	0.8	0.8	0.8	0.8	0.9
Fuel Combustion					
Residential	1.0	1.0	1.0	1.0	1.0
Commercial	0.6	0.5	0.5	0.5	0.4
Industrial					
Natural Gas	-	-	-	-	-
Other	3.9	4.8	5.0	5.5	6.3
Power Generation	7.9	22.7	31.6	36.7	39.2
Industrial Processes	2.7	3.1	3.4	3.7	4.0
Incineration/Miscellaneous	1.1	1.5	1.6	1.8	1.9
TOTAL	46.4	63.7	69.2	75.4	80.7

PROVINCE: Quebec

KILOTONNES (as NO_2)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	72.6	50.3	32.7	30.5	32.4
Light-Duty Trucks					
Gas	8.5	11.0	10.8	10.4	10.6
Diesel	0.5	0.6	0.6	0.7	0.9
Heavy-Duty Trucks					
Gas	3.1	2.1	1.1	0.9	0.9
Diesel	28.7	47.9	37.1	35.9	39.1
Off-Road Diesel					
Construction	3.6	4.3	4.9	5.2	5.5
Agriculture	4.4	5.4	5.8	6.2	6.7
Railroads	16.9	11.5	11.6	11.4	11.4
Other	21.1	24.6	26.3	27.5	28.1
Other	16.4	17.3	17.9	18.6	19.9
Fuel Combustion					
Residential	7.5	6.1	5.3	4.5	4.1
Commercial	3.9	4.7	4.7	4.6	4.6
Industrial					
Natural Gas	-	-	-	-	-
Other	21.3	24.6	26.0	28.0	29.4
Power Generation	1.5	3.8	3.3	3.3	3.3
Industrial Processes	6.8	7.8	8.8	10.0	11.3
Incineration/Miscellaneous	6.0	7.3	8.2	9.0	10.1
TOTAL	222.8	229.3	205.1	206.7	218.3

PROVINCE: Ontario

KILOTONNES (as NO_2)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	134.4	95.3	65.0	56.7	59.6
Light-Duty Trucks					
Gas	33.0	32.4	32.6	31.9	33.4
Diesel	2.3	2.8	2.8	3.5	4.5
Heavy-Duty Trucks					
Gas	2.0	1.2	0.7	0.7	0.7
Diesel	82.6	102.4	78.7	75.8	83.2
Off-Road Diesel					
Construction	9.1	10.9	13.7	17.1	21.5
Agriculture	7.4	7.5	8.0	8.2	8.6
Railroads	30.3	26.0	26.3	26.0	26.0
Other	27.2	31.7	34.7	34.9	34.3
Other	20.2	22.0	23.1	23.7	24.4
Fuel Combustion					
Residential	15.4	14.6	15.0	15.4	15.3
Commercial	9.7	9.5	10.4	10.5	11.0
Industrial					
Natural Gas	0.5	0.5	0.6	0.6	0.6
Other	45.1	50.1	58.2	63.7	70.5
Power Generation	97.6	74.9	83.4	114.6	94.8
Industrial Processes	38.2	40.5	47.6	54.2	62.3
Incineration/Miscellaneous	2.5	2.7	2.8	2.9	2.9
TOTAL	557.5	525.0	503.6	540.4	553.6

PROVINCE: Manitoba

KILOTONNES (as NO_2)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	17.1	12.7	8.7	7.1	6.9
Light-Duty Trucks					
Gas	6.1	4.8	4.0	3.7	3.9
Diesel	0.3	0.4	0.4	0.5	0.6
Heavy-Duty Trucks					
Gas	1.7	1.1	0.7	0.5	0.5
Diesel	16.2	21.1	17.2	17.4	20.2
Off-Road Diesel					
Construction	1.4	1.9	1.9	2.2	2.6
Agriculture	5.2	6.1	7.0	7.0	7.2
Railroads	17.2	15.4	15.5	15.4	15.4
Other	3.7	5.7	6.3	6.6	7.0
Other	4.3	4.3	4.3	4.4	4.6
Fuel Combustion					
Residential	1.5	1.3	1.3	1.3	1.3
Commercial	1.3	1.2	1.3	1.4	1.4
Industrial					
Natural Gas	-	-	-	-	-
Other	2.2	2.2	2.5	2.8	3.3
Power Generation	2.7	1.6	1.6	0.7	0.7
Industrial Processes	0.6	0.6	0.7	0.8	0.9
Incineration/Miscellaneous	0.4	0.4	0.4	0.5	0.5
TOTAL	81.9	80.8	73.8	72.3	77.0

PROVINCE: Saskatchewan

KILOTONNES (as NO_2)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	13.1	10.8	7.6	6.1	6.4
Light-Duty Trucks					
Gas	8.7	5.6	4.3	4.0	4.1
Diesel	0.4	0.6	0.6	0.7	0.9
Heavy-Duty Trucks					
Gas	2.7	1.6	0.9	0.7	0.8
Diesel	24.1	24.1	18.3	18.3	22.0
Off-Road Diesel					
Construction	2.6	2.5	2.6	2.9	3.4
Agriculture	14.9	17.6	19.0	21.0	23.5
Railroads	9.6	6.9	6.9	6.9	6.9
Other	7.4	8.5	9.6	10.3	10.4
Other	9.5	8.6	8.1	8.1	8.7
Fuel Combustion					
Residential	2.3	2.0	2.1	2.2	2.2
Commercial	1.1	1.1	1.3	1.4	1.5
Industrial					
Natural Gas	16.9	19.6	21.5	22.2	22.1
Other	4.8	4.5	5.1	5.8	6.4
Power Generation	36.1	43.6	47.8	45.6	44.0
Industrial Processes	0.9	1.0	1.1	1.2	1.4
Incineration/Miscellaneous	0.5	0.6	0.7	0.8	0.8
TOTAL	155.6	159.2	157.5	158.2	165.5

PROVINCE: Alberta

KILOTONNES (as NO$_2$)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	42.3	27.2	18.6	15.5	15.6
Light-Duty Trucks					
Gas	11.2	10.9	8.5	7.7	7.8
Diesel	0.6	0.7	0.7	0.9	1.1
Heavy-Duty Trucks					
Gas	3.5	2.9	1.8	1.5	1.8
Diesel	33.5	39.5	24.7	21.4	22.7
Off-Road Diesel					
Construction	8.1	6.3	6.4	7.4	8.8
Agriculture	17.1	20.6	21.1	22.3	24.0
Railroads	33.8	31.4	31.7	31.4	31.4
Other	25.2	21.9	26.0	29.5	30.9
Other	14.9	13.8	13.5	13.9	14.5
Fuel Combustion					
Residential	7.0	5.9	6.2	6.5	6.6
Commercial	4.5	4.5	4.8	5.1	5.2
Industrial					
Natural Gas	131.5	169.4	186.4	187.2	169.4
Other	11.3	13.8	18.0	18.4	19.0
Power Generation	68.1	106.3	112.7	122.4	127.0
Industrial Processes	26.2	21.8	25.6	31.3	39.3
Incineration/Miscellaneous	1.5	2.4	2.6	2.9	3.2
TOTAL	440.3	499.3	509.3	525.3	528.3

PROVINCE: British Columbia

KILOTONNES (as NO_2)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	46.6	37.5	26.1	20.4	19.4
Light-Duty Trucks					
Gas	17.3	12.7	10.5	9.6	9.9
Diesel	0.9	1.2	1.2	1.5	1.8
Heavy-Duty Trucks					
Gas	4.8	2.9	1.9	1.6	1.6
Diesel	48.2	44.2	29.8	26.8	28.7
Off-Road Diesel					
Construction	4.0	3.7	3.7	3.9	4.2
Agriculture	2.9	5.3	6.5	6.9	7.3
Railroads	16.8	13.4	13.5	13.4	13.4
Other	37.2	33.7	37.9	41.2	44.2
Other	6.7	8.2	8.4	8.6	9.2
Fuel Combustion					
Residential	3.6	3.2	3.2	3.3	3.3
Commercial	2.7	2.6	2.8	2.8	2.9
Industrial					
Natural Gas	9.9	10.3	12.0	12.9	13.1
Other	25.3	25.1	28.7	31.6	34.8
Power Generation	3.7	1.0	1.0	1.0	1.2
Industrial Processes	10.7	12.1	13.4	14.9	16.7
Incineration/Miscellaneous	11.3	11.1	11.6	12.6	13.7
TOTAL	252.6	228.2	212.2	213.0	225.4

PROVINCE: Yukon/North West Territories

KILOTONNES (as NO_2)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	0.5	0.4	0.3	0.2	0.2
Light-Duty Trucks					
Gas	0.7	0.5	0.4	0.4	0.4
Diesel	< 0.1	< 0.1	< 0.1	0.1	0.1
Heavy-Duty Trucks					
Gas	0.2	0.1	0.1	0.1	0.1
Diesel	2.3	2.1	1.4	1.3	1.4
Off-Road Diesel					
Construction	0.8	0.9	1.0	1.1	1.3
Agriculture	< 0.1	0.1	0.1	0.1	0.1
Railroads	0.1	0.1	0.1	0.1	0.1
Other	5.9	5.3	6.0	6.5	7.0
Other	1.6	2.0	2.1	2.2	2.3
Fuel Combustion					
Residential	0.2	0.2	0.2	0.2	0.2
Commercial	0.3	0.3	0.2	0.2	0.2
Industrial					
Natural Gas	-	-	-	-	-
Other	0.2	0.1	0.1	0.2	0.2
Power Generation	3.2	4.4	5.4	6.9	8.5
Industrial Processes	-	-	-	-	-
Incineration/Miscellaneous	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TOTAL	16.0	16.6	17.5	19.6	22.1

VOC Emission Projections - Assumptions

A. Base Year: 1985

Sources of Data (base year):

- motor vehicles
  - population - Statistics Canada
    - Transportation Systems Division (TSD), Environment Canada
  - emission factors - TSD
    - new MOBILE4 data
  - vehicle miles travelled - TSD
- other transportation
  - fuel consumption - Statistics Canada
  - emission factors - U.S. EPA (AP-42)
    - Railway Association of Canada (RAC)
- fuel combustion
  - fuel consumption - Statistics Canada
  - emission factors - U.S. EPA .
  - petroleum refineries:
    - emissions - provided by refineries and provinces
    - emission factors - U.S. EPA
  - natural gas processing:
    - emissions calculated using emission factors from U.S. EPA and fuel consumption from provincial agencies
- power generation emissions, fuel consumption from major plants (provincial utilities) used with U.S. EPA emission factors
  - additional emissions from small stations and gas turbines calculated from fuel consumption data and U.S. EPA emission factors
- industrial processes:
  - emissions data from 1985 inventory
  - petroleum refinery emission data based on PACE statistics + provincial information
  - petrochemical industry emissions based on a joint Environment Canada/Canadian Chemical Producers Association (CCPA) survey of the larger petrochemical plants. The findings from this survey were used to estimate the emissions from the whole petrochemical sector.
  - plastics industry emissions data and emission factors provided by the Environment and Plastics Institute of Canada (EPIC)
  - data generated either through provincial agencies (point sources) or Statistics Canada production figures

- incineration/miscellaneous:
    - 1985 emissions data - emissions calculated by use of Statistics Canada data with emission factors
    - emission estimates from the use of solvents obtained from consultants

B. Forecast Years: 1986-2005

Sources of data:

- motor vehicles
    - emission factors - TSD
    - growth in car/truck stock by fuel type
    - National Energy Board (NEB) transportation model
    - Motor Vehicle Manufacturers Assoc. (MVMA) sales forecasts
    - assumes no change in vehicle miles travelled

- other transportation
    - growth in energy consumption (e.g., 1987 vs. 1985 values) - NEB
    - province-specific statistics
    - assumes no change in emission factors or level of control technology available
    - RAC projections of fuel demand and emissions in the rail sector

- fuel combustion
    - industrial/commercial/residential
    - growth in energy consumption (for each fuel) - NEB
    - province-specific statistics
    - assumes no change in emission factors or level of control technology available

- petroleum refineries (fuel combustion)
    - growth in energy demand petroleum products) - NEB
    - no changes in emission factors or level of control technology

- natural gas processing (fuel combustion)
    - Informetrica GDP growth rates for "Petroleum & Gas-Resources Extraction"
    - assumes no changes in emission factors or level of control technology

- power generation
    - emissions assumed to be constant throughout forecast period

- Industrial processes
    - Informetrica GDP growth rates used for following sectors:

Bakeries - "Food and Beverage" sector
Petrochemicals - "chemicals" sector - [the forecast assumes that the growth in capacity to the year 2005 would be taken up by plants emiting at a rate comparable to that of current new capacity.]
Metallurgical coke - "Petroleum & coal products - manufacturing" sector
Aluminum production - "Primary metals" sector
Sulphate pulping - "Pulp & paper" sector
Tar sands - "Mining services" sector
Crude oil production - "Petroleum and gas - resource extraction" sector
Carbon black - "Chemicals" sector
Pulpboard manufacture - "Wood-manufacture" sector
Plywood, veneer - "Wood-manufacture" sector

-data for growth rates are province-specific

- petroleum refineries - growth in energy demand (petroleum products) - NEB
- plastics - growth rates obtained from the EPIC (not province-specific)

- incineration/miscellaneous
    - population growth rates for growth in incineration practices
    - wigwam burners - Informetrica GDP growth rates - "Wood manufacturing"
    - slash burning - Informetrica GDP gtowth rates - "Forestry"
    - gasoline marketing - NEB (1988) forescasts in motor gasoline consumption
    - structural fires - Informetrica growth for "households"
    - solvent use - Statistics Canada growth in "population"
    - surface coatings - Informetrica growth for "households"
    - dry cleaning - Statistics Canada growth in "population"

Note: All growth rates are for a "high growth" scenario as forecast by the NEB. Informetrica growth rates are based on their most recent tabulations from their economic model.

NO$_X$/VOC EMISSION FORECAST 90-B

VOLATILE ORGANIC COMPOUNDS (VOCs)

CANADA

KILOTONNES (as total non-methane hydrocarbons)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	412.7	334.0	256.1	229.4	237.3
Light-Duty Trucks					
Gas	142.7	127.9	113.7	104.8	108.9
Diesel	1.4	2.1	2.1	2.9	3.7
Heavy-Duty Trucks					
Gas	25.1	9.9	5.5	4.2	4.3
Diesel	28.7	30.4	33.4	37.7	43.5
Off-Road Gasoline	66.1	64.8	66.5	70.3	74.3
Other	72.6	76.1	79.5	82.8	89.0
Fuel Combustion					
Fuelwood	107.7	111.8	119.3	128.5	132.7
Residential/Commercial	3.7	3.5	3.5	3.5	3.5
Industrial	49.5	46.0	52.1	57.3	63.9
Industrial Processes					
Petrochemicals	36.4	37.5	40.5	45.3	51.3
Petroleum Refining	40.3	42.7	44.4	46.5	49.3
Plastics	13.6	16.0	20.9	25.6	29.4
Crude Oil	15.0	14.9	18.2	26.2	28.3
Other	46.7	51.2	62.1	71.1	81.1
Incineration/Miscellaneous					
Surface Coatings	187.5	207.5	223.9	238.7	253.6
Fuel Marketing	109.0	109.0	113.7	119.1	124.4
Dry Cleaning	14.0	14.5	15.0	15.3	15.5
Solvent Use	300.5	314.0	323.6	329.9	333.8
Slash Burning	80.6	89.8	101.7	113.6	129.0
Other	25.6	25.7	28.0	29.7	32.4
Power Generation	2.7	2.7	2.7	2.7	2.7

NO_x/VOC EMISSION FORECAST 90-B

VOLATILE ORGANIC COMPOUNDS (VOCs)

PROVINCE: Newfoundland

KILOTONNES (as total non-methane hydrocarbons)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	5.1	3.7	2.5	2.3	2.4
Light-Duty Trucks					
Gas	2.8	2.4	2.1	1.9	2.0
Diesel	< 0.1	< 0.1	< 0.1	0.1	0.1
Heavy-Duty Trucks					
Gas	0.7	0.2	0.1	0.1	0.1
Diesel	0.6	0.8	0.9	1.1	1.2
Off-Road Gasoline	2.7	2.9	3.1	3.5	3.8
Other	2.3	2.4	2.6	2.7	2.8
Fuel Combustion					
Fuelwood	8.7	8.7	9.1	9.4	9.8
Residential/Commercial	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Industrial	< 0.1	0.1	0.1	0.1	0.1
Industrial Processes					
Petrochemicals	-	-	-	-	-
Petroleum Refining	-	-	-	-	-
Plastics	< 0.1	< 0.1	< 0.1	< 0.1	0.1
Crude Oil	-	-	1.7	9.0	11.0
Other	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Incineration/Miscellaneous					
Surface Coatings	2.8	3.0	3.3	3.4	3.5
Fuel Marketing	1.9	1.9	2.0	2.0	2.1
Dry Cleaning	0.3	0.3	0.3	0.4	0.4
Solvent Use	6.0	6.4	6.7	7.0	7.2
Slash Burning	1.4	1.7	1.8	2.0	2.5
Other	0.1	0.1	0.1	0.1	0.1
Power Generation	0.2	0.2	0.2	0.2	0.2
TOTAL	35.6	34.7	36.5	45.2	49.3

NO$_x$/VOC EMISSION FORECAST 90-B — VOLATILE ORGANIC COMPOUNDS (VOCs)

PROVINCE: Prince Edward Island — KILOTONNES (as total non-methane hydrocarbons)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	1.7	1.3	0.9	0.8	0.9
Light-Duty Trucks					
Gas	0.7	0.6	0.6	0.5	0.5
Diesel	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Heavy-Duty Trucks					
Gas	0.2	0.1	< 0.1	< 0.1	< 0.1
Diesel	0.2	0.2	0.2	0.3	0.3
Off-Road Gasoline	0.2	0.2	0.2	0.2	0.2
Other	0.1	0.2	0.2	0.2	0.2
Fuel Combustion					
Fuelwood	4.5	4.5	4.7	4.9	5.0
Residential/Commercial	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Industrial	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Industrial Processes					
Petrochemicals	-	-	-	-	-
Petroleum Refining	-	-	-	-	-
Plastics	-	-	-	-	-
Crude Oil	-	-	-	-	-
Other	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Incineration/Miscellaneous					
Surface Coatings	1.1	1.2	1.2	1.2	1.3
Fuel Marketing	0.6	0.6	0.6	0.6	0.7
Dry Cleaning	0.1	0.1	0.1	0.1	0.1
Solvent Use	1.3	1.4	1.4	1.5	1.5
Slash Burning	0.2	0.3	0.3	0.3	0.4
Other	0.1	0.1	0.1	0.1	0.1
Power Generation	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TOTAL	11.0	10.8	10.5	10.7	11.2

VOLATILE ORGANIC COMPOUNDS (VOCs)

PROVINCE: Nova Scotia

KILOTONNES (as total non-methane hydrocarbons)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	11.3	8.4	6.1	5.5	5.7
Light-Duty Trucks					
Gas	5.5	4.7	4.1	3.8	3.9
Diesel	0.1	0.1	0.1	0.1	0.1
Heavy-Duty Trucks					
Gas	1.2	0.4	0.2	0.1	0.1
Diesel	1.4	1.7	2.1	2.4	2.8
Off-Road Gasoline	0.9	0.9	0.9	1.0	1.1
Other	2.1	2.3	2.5	2.6	3.0
Fuel Combustion					
Fuelwood	4.6	4.6	4.8	5.0	5.2
Residential/Commercial	0.3	0.3	0.3	0.3	0.3
Industrial	< 0.1	< 0.1	< 0.1	< 0.1	0.1
Industrial Processes					
Petrochemicals	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Petroleum Refining	3.2	3.5	3.6	3.8	4.1
Plastics	0.1	0.1	0.1	0.2	0.2
Crude Oil	0.7	0.5	0.2	0.1	0.1
Other	0.2	0.3	0.3	0.3	0.4
Incineration/Miscellaneous					
Surface Coatings	4.6	5.0	5.2	5.3	5.4
Fuel Marketing	3.7	3.8	3.9	4.0	4.2
Dry Cleaning	0.5	0.5	0.5	0.5	0.5
Solvent Use	9.3	9.6	9.8	10.0	10.1
Slash Burning	2.0	2.6	2.9	3.1	3.4
Other	0.4	0.4	0.4	0.4	0.5
Power Generation	0.1	0.1	0.1	0.1	0.1
TOTAL	52.2	49.8	48.1	48.6	51.3

NO_x/VOC EMISSION FORECAST 90-B

VOLATILE ORGANIC COMPOUNDS (VOCs)

PROVINCE: New Brunswick

KILOTONNES (as total non-methane hydrocarbons)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	8.9	6.6	4.7	4.2	4.3
Light-Duty Trucks					
Gas	4.5	3.9	3.4	3.1	3.2
Diesel	< 0.1	0.1	0.1	0.1	0.1
Heavy-Duty Trucks					
Gas	1.0	0.3	0.1	0.1	0.1
Diesel	1.0	1.2	1.5	1.7	1.9
Off-Road Gasoline	0.8	0.8	0.8	0.9	0.9
Other	1.4	1.6	1.6	1.7	2.0
Fuel Combustion					
Fuelwood	5.3	5.2	5.5	5.7	5.9
Residential/Commercial	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Industrial	< 0.1	0.1	0.1	0.1	0.1
Industrial Processes					
Petrochemicals	-	-	-	-	-
Petroleum Refining	1.3	1.4	1.4	1.5	1.6
Plastics	0.1	0.2	0.2	0.3	0.3
Crude Oil	0.5	0.5	0.6	0.6	0.6
Other	0.6	0.7	0.8	0.9	1.0
Incineration/Miscellaneous					
Surface Coatings	3.8	4.1	4.3	4.4	4.4
Fuel Marketing	3.2	3.3	3.4	3.5	3.7
Dry Cleaning	0.4	0.4	0.4	0.4	0.5
Solvent Use	7.5	7.8	8.1	8.3	8.5
Slash Burning	4.5	6.3	7.0	7.6	8.1
Other	0.5	0.5	0.6	0.6	0.6
Power Generation	0.1	0.1	0.1	0.1	0.1
TOTAL	45.4	45.1	44.7	45.8	47.9

NO_x/VOC EMISSION FORECAST 90-B

VOLATILE ORGANIC COMPOUNDS (VOCs)

PROVINCE: Quebec

KILOTONNES (as total non-methane hydrocarbons)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	81.9	63.3	46.3	44.0	46.2
Light-Duty Trucks					
Gas	12.2	15.1	14.5	13.4	13.7
Diesel	0.1	0.2	0.2	0.2	0.3
Heavy-Duty Trucks					
Gas	3.6	1.5	0.7	0.5	0.5
Diesel	3.1	4.5	5.2	5.9	6.7
Off-Road Gasoline	4.8	5.0	5.5	5.9	6.4
Other	10.4	10.6	11.1	11.7	12.6
Fuel Combustion					
Fuelwood	39.9	46.7	50.0	51.5	53.5
Residential/Commercial	0.4	0.4	0.4	0.3	0.3
Industrial	0.3	0.3	0.4	0.4	0.4
Industrial Processes					
Petrochemicals	5.9	6.2	6.5	7.1	7.7
Petroleum Refining	7.1	7.5	7.7	8.0	8.4
Plastics	3.5	4.1	5.4	6.6	7.6
Crude Oil	0.7	0.6	0.6	0.6	0.6
Other	8.3	9.1	10.3	11.3	12.7
Incineration/Miscellaneous					
Surface Coatings	48.5	53.9	57.3	60.1	62.5
Fuel Marketing	23.3	23.3	24.9	26.3	27.2
Dry Cleaning	3.6	3.7	3.8	3.8	3.8
Solvent Use	69.1	70.8	72.0	72.3	72.2
Slash Burning	20.2	26.2	30.0	33.9	38.7
Other	8.8	9.2	9.7	10.0	10.5
Power Generation	0.1	0.1	0.1	0.1	0.1
TOTAL	355.8	362.3	362.6	373.9	392.6

VOLATILE ORGANIC COMPOUNDS (VOCs)

PROVINCE: Ontario

KILOTONNES (as total non-methane hydrocarbons)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	154.9	129.4	101.3	92.5	97.6
Light-Duty Trucks					
Gas	50.8	50.1	49.1	46.8	49.2
Diesel	0.6	0.8	0.8	1.2	1.6
Heavy-Duty Trucks					
Gas	2.3	0.9	0.6	0.4	0.4
Diesel	8.9	9.6	10.9	12.4	14.3
Off-Road Gasoline	19.4	20.6	22.7	24.2	25.4
Other	21.6	23.1	23.5	23.5	24.3
Fuel Combustion					
Fuelwood	33.9	31.2	33.8	40.4	41.4
Residential/Commercial	1.1	1.1	1.2	1.2	1.3
Industrial	1.1	1.1	1.3	1.4	1.5
Industrial Processes					
Petrochemicals	18.2	18.7	19.9	21.6	23.4
Petroleum Refining	15.4	16.7	18.1	19.1	20.2
Plastics	8.1	9.4	12.4	15.1	17.4
Crude Oil	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Other	30.4	32.7	39.2	45.6	53.3
Incineration/Miscellaneous					
Surface Coatings	83.3	94.6	105.5	116.2	127.0
Fuel Marketing	41.6	44.3	48.8	51.9	54.6
Dry Cleaning	5.0	5.3	5.5	5.6	5.7
Solvent Use	129.6	136.9	141.8	145.2	147.2
Slash Burning	0.5	0.6	0.7	0.8	1.0
Other	4.2	4.6	5.1	5.5	6.0
Power Generation	0.4	0.4	0.4	0.4	0.4
TOTAL	631.3	634.1	642.6	671.0	713.2

NO$_x$/VOC EMISSION FORECAST 90-B

VOLATILE ORGANIC COMPOUNDS (VOCs)

PROVINCE: Manitoba

KILOTONNES (as total non-methane hydrocarbons)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	22.2	18.5	14.2	11.8	11.5
Light-Duty Trucks					
Gas	9.3	7.3	6.0	5.4	5.6
Diesel	0.1	0.1	0.1	0.2	0.2
Heavy-Duty Trucks					
Gas	1.9	0.8	0.5	0.3	0.3
Diesel	1.8	2.0	2.4	2.8	3.5
Off-Road Gasoline	4.6	4.3	4.3	4.4	4.7
Other	3.9	4.2	4.3	4.6	4.9
Fuel Combustion					
Fuelwood	1.9	1.5	1.5	1.4	1.3
Residential/Commercial	0.3	0.3	0.2	0.2	0.2
Industrial	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Industrial Processes					
Petrochemicals	-	-	-	-	-
Petroleum Refining	-	-	-	-	-
Plastics	0.3	0.4	0.5	0.6	0.7
Crude Oil	0.1	0.1	0.2	0.2	0.1
Other	0.3	0.3	0.4	0.4	0.4
Incineration/Miscellaneous					
Surface Coatings	5.8	6.3	6.4	6.4	6.5
Fuel Marketing	4.6	4.2	4.0	4.1	4.2
Dry Cleaning	0.6	0.6	0.6	0.6	0.6
Solvent Use	11.3	11.8	12.0	12.0	12.0
Slash Burning	1.0	1.4	1.5	1.8	2.0
Other	0.6	0.7	0.7	0.7	0.7
Power Generation	0.4	0.4	0.4	0.4	0.4
TOTAL	71.0	65.2	60.2	58.3	59.8

NO$_x$/VOC EMISSION FORECAST 90-B

VOLATILE ORGANIC COMPOUNDS (VOCs)

PROVINCE: \Saskatchewan

KILOTONNES (as total non-methane hydrocarbons)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	17.3	15.9	12.5	10.2	10.7
Light-Duty Trucks					
Gas	13.4	8.7	6.5	5.8	6.0
Diesel	0.1	0.2	0.2	0.2	0.3
Heavy-Duty Trucks					
Gas	3.1	1.1	0.6	0.5	0.5
Diesel	2.6	2.3	2.5	3.0	3.8
Off-Road Gasoline	10.2	9.1	8.6	9.0	9.8
Other	6.0	5.7	6.0	6.5	7.0
Fuel Combustion					
Fuelwood	2.3	2.1	2.2	2.3	2.2
Residential/Commercial	0.3	0.2	0.2	0.2	0.2
Industrial	0.1	0.1	0.1	0.1	0.1
Industrial Processes					
Petrochemicals	-	-	-	-	-
Petroleum Refining	1.7	1.6	1.5	1.6	1.8
Plastics	0.1	0.1	0.1	0.1	0.1
Crude Oil	1.9	2.3	2.5	2.6	2.5
Other	0.4	0.4	0.5	0.6	0.7
Incineration/Miscellaneous					
Surface Coatings	5.1	5.4	5.5	5.5	5.4
Fuel Marketing	4.5	4.0	3.7	3.9	4.2
Dry Cleaning	0.6	0.6	0.7	0.7	0.7
Solvent Use	10.8	11.5	12.0	12.4	12.8
Slash Burning	1.7	2.8	3.2	3.6	4.1
Other	0.4	0.4	0.5	0.5	0.5
Power Generation	0.3	0.3	0.3	0.3	0.3
TOTAL	82.9	74.8	69.9	69.6	73.7

NO_x/VOC EMISSION FORECAST 90-B | **VOLATILE ORGANIC COMPOUNDS (VOCs)**

PROVINCE: Alberta

KILOTONNES (as total non-methane hydrocarbons)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	50.4	34.1	25.6	21.8	22.1
Light-Duty Trucks					
Gas	16.1	15.0	11.4	9.8	10.0
Diesel	0.2	0.2	0.2	0.3	0.4
Heavy-Duty Trucks					
Gas	3.9	1.9	1.1	0.9	1.0
Diesel	3.6	3.7	3.4	3.5	3.9
Off-Road Gasoline	16.9	15.4	14.8	15.4	15.9
Other	12.1	11.7	12.1	12.8	14.0
Fuel Combustion					
Fuelwood	1.5	1.5	1.6	1.7	1.7
Residential/Commercial	1.0	0.9	0.9	1.0	0.9
Industrial	5.3	5.1	5.7	5.9	5.8
Industrial Processes					
Petrochemicals	11.0	11.2	12.6	15.0	18.5
Petroleum Refining	5.3	5.5	5.7	6.0	6.3
Plastics	0.7	0.8	1.1	1.3	1.5
Crude Oil	10.5	10.0	11.2	11.5	11.2
Other	0.5	0.6	0.7	0.8	0.9
Incineration/Miscellaneous					
Surface Coatings	10.7	11.1	11.2	11.5	12.0
Fuel Marketing	12.9	11.7	11.1	11.5	11.8
Dry Cleaning	1.3	1.3	1.4	1.4	1.4
Solvent Use	24.8	25.0	25.8	26.5	27.1
Slash Burning	5.1	7.6	8.8	9.9	11.3
Other	1.4	1.5	1.6	1.6	1.8
Power Generation	0.6	0.6	0.6	0.6	0.6
TOTAL	195.8	176.4	165.6	170.7	180.1

NO$_x$/VOC EMISSION FORECAST 90-B

VOLATILE ORGANIC COMPOUNDS (VOCs)

PROVINCE: British Columbia

KILOTONNES (as total non-methane hydrocarbons)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	58.3	52.2	41.5	35.9	35.5
Light-Duty Trucks					
Gas	26.3	19.3	15.4	13.7	14.2
Diesel	0.2	0.4	0.4	0.5	0.6
Heavy-Duty Trucks					
Gas	6.9	2.6	1.5	1.2	1.2
Diesel	5.2	4.2	4.1	4.4	4.9
Off-Road Gasoline	5.2	5.2	5.2	5.4	5.7
Other	11.7	13.3	14.5	15.3	17.0
Fuel Combustion					
Fuelwood	3.8	4.3	4.5	4.6	5.0
Residential/Commercial	0.3	0.3	0.3	0.3	0.3
Industrial	42.7	39.2	44.4	49.3	55.8
Industrial Processes					
Petrochemicals	1.3	1.4	1.5	1.6	1.7
Petroleum Refining	6.3	6.5	6.4	6.5	6.9
Plastics	0.7	0.9	1.1	1.4	1.6
Crude Oil	0.4	0.4	0.5	0.5	0.5
Other	6.0	7.1	9.9	11.2	11.7
Incineration/Miscellaneous					
Surface Coatings	21.5	22.6	23.7	24.4	25.2
Fuel Marketing	12.4	11.6	11.0	11.0	11.4
Dry Cleaning	1.6	1.7	1.7	1.8	1.8
Solvent Use	30.3	32.0	33.1	33.8	34.3
Slash Burning	43.9	40.2	45.4	50.5	57.4
Other	9.1	8.2	9.2	10.2	11.5
Power Generation	0.3	0.3	0.3	0.3	0.3
TOTAL	294.4	273.9	275.6	283.8	304.5

NO$_x$/VOC EMISSION FORECAST 90-B

VOLATILE ORGANIC COMPOUNDS (VOCs)

PROVINCE: Yukon/North West Territories

KILOTONNES (as total non-methane hydrocarbons)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	0.7	0.6	0.5	0.4	0.4
Light-Duty Trucks					
Gas	1.1	0.8	0.6	0.6	0.6
Diesel	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Heavy-Duty Trucks					
Gas	0.3	0.1	0.1	0.1	0.1
Diesel	0.3	0.2	0.2	0.2	0.2
Off-Road Gasoline	0.4	0.4	0.4	0.4	0.4
Other	1.0	1.0	1.1	1.2	1.2
Fuel Combustion					
Fuelwood	1.3	1.5	1.6	1.6	1.7
Residential/Commercial	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Industrial	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Industrial Processes					
Petrochemicals	-	-	-	-	-
Petroleum Refining	-	-	-	-	-
Plastics	-	-	-	-	-
Crude Oil	0.2	0.5	0.7	1.1	1.7
Other	-	-	-	-	-
Incineration/Miscellaneous					
Surface Coatings	0.3	0.3	0.3	0.3	0.4
Fuel Marketing	0.3	0.3	0.3	0.3	0.3
Dry Cleaning	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Solvent Use	0.8	0.9	0.9	0.9	0.9
Slash Burning	0.1	0.1	0.1	0.1	0.1
Other	< 0.1	< 0.1	< 0.1	< 0.1	0.1
Power Generation	0.2	0.2	0.2	0.2	0.2
TOTAL	7.0	6.8	7.0	7.4	8.3

APPENDIX B

AIR QUALITY OBJECTIVES

TABLE 1.2
CURRENT AND RECOMMENDED (a) NATIONAL AMBIENT AIR QUALITY OBJECTIVES AND CRITICAL LEVELS FOR OXIDANTS (OZONE), NITROGEN DIOXIDE, AMMONIA AND SULPHUR DIOXIDE

	AIR QUALITY OBJECTIVES			CRITICAL LEVELS (e)		
Contaminant	Current Air Quality Objectives	Recommended Air Quality Objectives	Exposure Period	Exposure (duration in hours)	Concentrations ug/m3	ppm
Oxidants (Ozone)				0.5	300	0.150
maximum desirable levels	30 ug/m3 (0.015 ppm) 100 ug/m3 (0.05)	100 ug/m3[b] (0.05 ppm)	24-hour 1-hour	1.0	150	0.075
maximum acceptable levels	50 ug/m3 (0.025 ppm) 160 ug/m3 (0.08 ppm) 30 ug/m3 (0.015 ppm) (c)	160 ug/m3[b] (0.08 ppm) 64 ug/m3[b] (0.032 ppm)(d)	24-hour 1-hour annual seasonal mean	2.0 4.0 8.0	110 80 60	0.055 0.040 0.030
maximum tolerable levels	300 ug/m3 (0.15 ppm)	400 ug/m3 (0.2 ppm)	1-hour	Vegetation/Growing Period (Average of 7-hour mean/day, 9 a.m. to 4 p.m.)	50	0.025
Nitrogen Dioxide						
maximum desirable levels	60 ug/m3 (0.03 ppm)	60 ug/m3 (0.03 ppm)	annual			
maximum acceptable levels	100 ug/m3 (0.05 ppm) 200 ug/m3 (0.11 ppm) 400 ug/m3 (0.21 ppm)	100 ug/m3 (0.05 ppm) 400 ug/m3[b] (0.21 ppm)	annual 24-hour 1-hour	annual 4-hour	30 ug/m3[f] 95 ug/m3[f]	
maximum tolerable levels	300 ug/m3 (0.16 ppm) 1000 ug/m3 (0.53 ppm)	1000 ug/m3[b] (0.53 ppm)	24-hour 1-hour			
Ammonia	No air quality objectives			monthly 24-hour 1-hour	100 ug/m3 600 ug/m3 10,000 ug/m3	(0.14 ppm) (0.86 ppm) (14.3 ppm)
Sulphur Dioxide						
maximum desirable levels	30 ug/m3 (0.01 ppm) 150 ug/m3 (0.06 ppm) 450 ug/m3 (0.17 ppm)	30 ug/m3 (0.01 ppm) 150 ug/m3 (0.06 ppm) 450 ug/m3 (0.17 ppm)	annual 24-hour 1-hour			
maximum acceptable levels	60 ug/m3 (0.02 ppm) 300 ug/m3 (0.11 ppm) 900 ug/m3 (0.34 ppm)	60 ug/m3 (0.02 ppm) 300 ug/m3 (0.11 ppm) 900 ug/m3 (0.34 ppm)	annual 24-hour 1-hour	annual 4-hour	30 ug/m3[g] 95 ug/m3[g]	
maximum tolerable levels	800 ug/m3 (0.3 ppm)	800 ug/m3 (0.3 ppm)	24 hour			

(a) Recommendations have been made by the CCREM Federal-Provincial Advisory Committee on Air Quality to the Federal Department of the Environment.

(b) The recommendation is to rescind the current objective.

(c) There currently is no seasonal objective for ozone.

(d) A maximum acceptable level seasonal mean is recommended to prevent significant injury to the most susceptible vegetation during the peak growing months. The recommended level is near the levels occurring at the ground in rural areas due to natural sources of ozone.

(e) ECE draft critical levels.

(f) Nitrogen dioxide in combination with sulphur dioxide and ozone, as oxides of nitrogen are never found in isolation in the atmosphere.

TABLE 1.3
CANADIAN* AIR QUALITY REQUIREMENTS

	NITROGEN DIOXIDE (micrograms per cubic metre of ambient air)			OZONE (micrograms per cubic metre of air)		
	ANNUAL MEAN	24-HOUR AVERAGE	1-HOUR AVERAGE	ANNUAL MEAN	24-HOUR AVERAGE	1-HOUR AVERAGE
NATIONAL						
maximum desirable level	60				30	100
maximimum acceptable level	100	200	400	30	50	160
maximum tolerable level		300	1000			300
BRITISH COLUMBIA						
Level A						
Level B						
Level C						
ALBERTA						
maximum permissible concentrations	60	200	400		50	160
SASKATCHEWAN						
present standard	100	200	400		30	100
proposed standard					50	160
MANITOBA						
maximum desirable level	60				30	100
maximum acceptable level	100	200	400	30	50	160
maximum tolerable level			1000			400
ONTARIO						
ambient air criteria		200	400			165
QUEBEC						
ambient air standard	103	207	414			157
Montreal Urban Community standard **	100	200	400			
NEW BRUNSWICK						
maximum permissible ground level concentration	100	200	400			
NOVA SCOTIA ***						
PRINCE EDWARD ISLAND						
NEWFOUNDLAND						
acceptable criteria		200	400	30	50	160

* Prince Edward Island, the Northwest Territories and the Yukon Territory do not have air quality requirements specific to their jurisdictions.

** The Montreal Urban Community also has an 8-hour standard of 253 ug/m^3.

*** Nova Scotia uses the National Ambient Air Quality Objectives but has not legally adopted them.

APPENDIX C

EXISTING NOX/VOC REGULATIONS

Tables 2-1, 2-2, 2-3, and 2-4 summarize the existence of emission standards for various sources of NO_X and VOC. Further details are provided in the Work Sub-Group reports and related literature.

Although the information presented should be confirmed with the responsible regulatory authorities, Tables 2 do provide a preliminary overview of the existence of emission standards for various NOx and VOC sources, in Canada and other countries. (Blanks in the tables indicate that no known emission standards existed for that source or jurisdiction.)

Table 2.1.1a - Status of Emissions Standards - Canada
New* Mobile Sources - NOx, VOC

Source	CAN	OTHER	NOTES
■ Gasoline Fuel	R (1)		(1) Environment Canada Lead in Gasoline-Lower Level announced Can. Gazette Part 1, July 15, 1989.
■ Diesel Fuel	R (2)		(2) Environment Canada Sulphur in Diesel limitation - Expected announcement Can. Gazette, Part 1, Sept, 1990.
■ Light Duty Gasoline Vehicle (LDGV)	R (3)		(3) Transport Canada-Current standards in effect Sept 1, 1987.
■ Heavy Duty Vehicles (HDV)	R (4)		(4) Transport Canada-Current standards in effect Dec 1, 1988.
■ Heavy Duty Diesel Vehicle (HDDV)	R (5)		(5) Transport Canada-more stringent regulation contingent on Environment Canada sulphur in diesel limits (2). Sulphur in diesel affects particulate control systems.
■ Off-Road Diesel Equip. (Farm, Construction etc.)	(6)		(6) Legislative authority required to regulate.
■ Miscellaneous Gasoline Engines	(6)		(6)
■ Stationary Reciprocating Engines-Diesel	(7)	(7)	(7) Legislative authority required. Some provinces may regulate.
■ Natural Gas Turbines	(8)	(8)	(8) Legislative authority required. Some provinces provinces may regulate, e.g. Alberta.
■ Rail, Marine Aircraft	(9)		(9) Legislative authority required to regulate. Transport Canada does not have authority now to impose International Civil Aircraft Organization (ICAO) standards.

*See Table 2.1.1b for In-Use Vehicle Standards

LEGEND

R - Regulation

( ) - Note Number

Table 2.1.1b - Status of Emission Standards - Canada
In-Use Vehicles

Province	NFLD	PEI	NS	NB	QUE	ONT	MAN	SASK	ALTA	BC	YUK	NWT
EMISSION CONTROL EQUIPMENT												
Anit-Tampering												
Legislation	Y	N	N	P	Y	Y	N	N	N	Y	I	I
Possible Date				1990								
Idle Emissions Specifications	N	N	N	N	N	Y	N	N	N	##	N	N
Aftermarket Catalyst Legislation	N	N	N	I	N	Y	N	N	N	I	N	N
Enforcement Program												
Annual I/M	N	N	N	I	N	I#	N	N	I	P	N	N
Spot Check	N	N	N		N	Y	N	N	N	P	N	N
On Resale	N	N	N		N	P*	N	N	N	I	N	N
Possible Date			?	?		#93/95 *90				90/91		
Anti-Misfuelling Legislation	Y	N	I	I	N	Y	N	N	N	N	N	N
INLET RESTRICTOR												
Legislation	Y	N	N	P	Y	Y	N	N	N	N	N	N
Enforcement Program	N	N	N	I	N	S	N	N	N	I	N	N
NOZZLE Tampering												
Legislation	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N
Enforcement Program	S	S	Y	Y	Y	Y	N	L	N	L	N	N
VISIBLE OR SMOKE Emissions Legislation												
LDV	N	N	?	Y	Y	Y	Y	Y	N	N	?	N
HDV	N	N	N	Y	Y	Y	Y	Y	N	Y	N	N
Enforcement Program	N	N	N	N	L	L	?	**	N	L	N	N
SAFETY CHECK												
Existing Leg.	Y	Y	Y	Y	Y	Y	Y	?	I	(C)	Y	N
Enforcement Program												
On Resale			N		N	Y	N	N	N	N	N	N
Spot Checks					Y	Y	Y	N	N	(C)	(C)	N
Annual	Y	Y	Y	Y	N	N	N	***	I	(C)	N	L
GASOLINE QUALITY												
CGSB Standards	N	Y	Y	N	N	Y	N	F	Y	F	F	N
Other	I				Y		Y			N		Y
RVP Standards	I		I	P		Y		F		I		

LEGEND:

Y - Yes
I/M - Inspection Maintenance

Y = Yes
P = Planned
? = Unknown at this time
R = Regulation

N = No
S = Spot Checks

I = Investigating
L = Limited Program
(C) = Commercial Vehicle only
( ) = Note Number

** = has never been applied to mobile sources
*** = program discontinued in 1984
F = Industry Reported to Follow Canadian Government Standards Board
= No idle specs., but list federal test standards in legislation.

Table 2.1.2 - Status of Emission Standards - International Mobile Sources - NOx, VOC

Source	USA	CALIF.	OTHER	NOTES	
■ Gasoline Fuel	R	R		(1)	Regulations of the U.S. Environmental Protection Agency (EPA) will influence all vehicles manufactured in USA and Canada. Generally California standards are move stringent than EPA standards.
■ Diesel Fuel	R(5)			(2)	Generally, European vehicle emissions standards are currently less stringent than North American requirements.
■ Light Duty gasoline Vehicles (LDGV)	R(1)	R(1)		(3)	Technical and economic feasibility studies are being conducted by California and EPA. Regulations for off-road diesels and other sources are expected.
■ Heavy Duty Gasoline Vehicles (HDGV)	R(1)	R(1)		(4)	The International Civil Aircraft Organization (ICAO) has noise and emission standards. Only the noise standards have been adopted as regulations by Canada.
■ Off-Road Diesel Equipment	D(3)	D(3)			
■ Stationary Reciprocating Engines-Diesel					
■ Gas Turbines					
■ Rail, Marine Aircraft				(5)	EPA limits diesel sulphur in fuel to 0.05percent by 1994.

LEGEND:

R - Regulation, D-Regulation being developed
G - Guideline

Table 2.2.1 - Status of Emission Standards - Canada Stationary Sources - NOx

Sources	CAN	NFLD	PEI	NS	NB	QUE	ONT	MAN	SASK	ALTA	BC	NWT	YUK
■ Electric Utility Boiler	G(1)	P(2)	P	P	P	R,P	R,C,P (3)	P	G,P (4)	G,P (4)	R,P		
■ Industrial Boilers	R(5)	P	P	P	P	P	P	P	P	P	P,G (6)		
■ Combustion Turbines (7)						P	P	P	P	P	P		

LEGEND:

R - Regulation; G - Guideline; P - Site-specific permit; C - Total emission cap

Table 2.2.1 - Notes

(1) Environment Canada issued Guidelines (1981) for NOx, SO_2 and particulates. It is expected that NOx emission levels will be lowered, to reflect performance of current technologies.

(2) Most provinces have site-specific permitting systems, but many do not have uniform or minimum emission standards.

(3) Ontario has imposed "caps" on utility SO_2 and NOx emissions.

(4) Alberta and Saskatchewan have regulatory requirements for new utility boilers which are similar to Environment Canada guidelines (1).

(5) Regulation for boilers at federal facilities (expected summer 1990), are being developed under the Canadian Environmental Protection Act, Part IV.

(6) British Columbia is developing emission guidelines for industrial boilers which will be applied to site-specific permits. (expected summer 1990).

(7) Some gas turbine manufacturers are voluntarily adopting California emission standards.

Table 2.2.2 - Status of Emission Standards - International (0) Stationary Sources - NOx

Sources	USA	CALIF.	EUR	FRG	JAP	NOTES
■ Electric Utility Boilers	R(1)	R(2)	R(3)	R(4)	R(5),P	(1) (2)
■ Industrial Boiler	R(6)	R	R(3)	R(4)	R(5)P,	
■ Combustion Turbines	R	(6)				

LEGEND:

R - Regulation, P - Site-specific permit

Table 2.2.2 - Notes

(1) US Environmental Protection Agency promulgated New Source Performance Standards (NSPS), (1977), for NOx, SO_2 and particulates. Under proposed amendments to the Clear Air Act, proposed in Summer 1989, reductions of SO_2 and NOx emissions from existing sources, are expected.

(2) California South Coast Air Quality regulations, in effect, prevent the use of coal or oil in utility boilers.

(3) The European Community Ordinance for Large Furnaces, applies to all boilers over 100 MW (thermal).

(4)(5) Emissions standards in Southern California, the Federal Republic of Germany (FRG) and Japan are the world's, most stringent.

(6) Some gas turbine manufacturers are voluntarily adopting California emission standards.

Table 2.3.1 - Status of Emission Standards - Canada Large Stationary Sources - VOC

Sources	CAN	NFLD	PEI	NS	NB	QUE	ONT	MAN	SASK	ALTA	BC	NWT	YUK	MUC
■ Crude Oil Production - Storage											G			
■ Petroleum														
- Storage					R(1)	R(2)	G			P(6)	G(8)			B(2)(4)
- Equip Leak										P(7)				B(
- Process														
■ Gasoline Distribution														
- Storage					R(1)	R(2)								B(2)(4)
- Serv. Stat. Deliveries														B(4)
- Vehicles Refuelling														
- Volatility Reduction					T	R	R(5)							
■ Petrochemical & Organic Chem.														
- Storage						R(2)	G			P(6)				B(2)(4)
- Equip Leak										P(7)				
■ Plastic Processing														
■ Pulp & Paper														
■ Wood Transformation														

LEGEND:

R - Regulation, G - Guideline, B - By-Law Montreal Urban Community, P - Site Specific Permit, T-Proposed Regulation

Table 2.3.1 - Notes

(1) NB regulation applies to tanks with capacity greater than 23.80 m^3 for liquids with true vapour pressure (TVP) greater than 10.3 kPa.

(2) Quebec and Montreal requirements apply to new tanks with capacity greater than 250 m^3 and TVP greater than 10kPa, and to existing tanks greater than 1500m^3 (or flow-through greater than 4,500m^3 for refineries) and TVP greater than 10kPa.

(3) Requires 90% reduction of asphalt Oxidation Emissions.

(4) Requires submerged loading for tank greater than 5m^3, storing Organic liquids.

(5) Gasoline volatility limited to 72kPa during summer 1989.

(6) In general applies to tanks over 15 m. diameter and with TVP greater than 21kPa.

(7) Requires an approved leak detection and repair program.

(8) Applies to petroleum product tanks having a capacity greater than 245 m^3 when the liquid TVP is greater than 10.5kPa.

Table 2.3.2 - Status of Emission Standards - International Large Stationary Sources - VOC (7)

Sources	USA	CO	GA	IA	ME	MD	NJ	TX	WA	CA
■ Crude Oil Production										
■ Petroleum Refining										
- Storage	C(1)N	R	R	R	R	R	R	R(P)	R	R
- Equip Leak	C,N	R	R	R		R		R(P)	R	R
- Process	C,(2)N	R	R					R(P)	R	R
■ Others	C(3)N(P)	R	R					R(P)	R	R
■ Gasoline Distribution										
- Storage	C(4),N	R	R	R	R	R	R	R(P)	R	R
- Serv. Stat. Deliveries	C		R		R	R	R	R(P)	R	R
- Vehicle Refuelling	C							R(P)		R
- Volatility Reduction	R(5)				R(6)	R(P)(6)	R(6)	R(7)		R(6)
■ Organic Chemical Industry	C(1)									
- Storage	N	R	R	R		R	R	R(P)		R
- Equip Leak	C,N			R				R(P)		R
- Process	N							R(P)		
■ Natural Gas Production										
Equip. Leak	C,N			R				R(P)		R
■ Rubber Products	C,N		R							R
■ Pharma-ceutical	C,N		R					R(P)		

LEGEND:

C - Control Technique Guidelines (CTG)
N - New Source Performance Standard (NSPS)
R - Regulations
(P) - Proposed

State regulations when not otherwise specified, are roughly equivalent to U.S. EPA Guidelines and Standards.

Table 2.3.2 - Notes

(1) Some provisions for tanks $> 151\ m^3$ with TVP $\geq$ 3.5 kPa, and others for tanks $75m^3$ with TVP $\geq$ 27.6kPa.

(2) Control Technique Guidelines (CTG) for Vacuum producing systems.

(3) CTG for process unit turnaround and Waste Water Systems NSPS proposed for Waste Water Systems.

(4) CTG bulk plants and terminals, NSPS for Bulk terminals.

(5) 9.0 PSI to 10.5 PSI (62 to 72 kPa)depending on regions.

(6) Reduction to 9 PSI (62kPa) for May to September.

(7) European standards were being complied at time of report printing.

Table 2.4 - Status of Emissions Standards - Canada International Miscellaneous Sources - VOC

Source	CANADA MUC (1)	UNITED STATES				EUROPE
		FEDERAL	CALIFORNIA	OTHER STATES	W. GERMANY	OTHER COUNTRIES
SURFACE COATING						YES/(P)
■ Paint Appl	B-L	CTG/NSPS	REG	YES(2)	REG	
■ Other Coatings App.	B-L	CTG/NSPS	REG	YES	REG	
■ Consumer Paints/ Coat			REG	YES		
GLUE/ADHESIVE APPLICATION						
■ Ind./Comm. Appl.		NSPS	REG			
■ Consumer Appl.			REG			
PRINTING				YES	YES	(P)
■ Flexogravure		CTG	REG			
■ Rotogravure		CTG	REG(?)			
■ Other			(?)			
DEGREASING				YES		(P)
(Ind./Comm.)	B-L	CTG/NSPS	REG			
DRY CLEANING				YES		(P)
■ Petroleum Based	B-L	CTG/NSPS	REG			
■ Perchloro Ethygene	B-L		REG			
CONSUMER PRODUCTS						
■ Car Products						
■ Household						
■ Personal Use			REG(P)			

LEGEND:

BL - By-Law; CTG Control Technique Guidelines; NSPS - New Source Performance Standard; REG - Regulation; (P) - Proposed

NOTES:

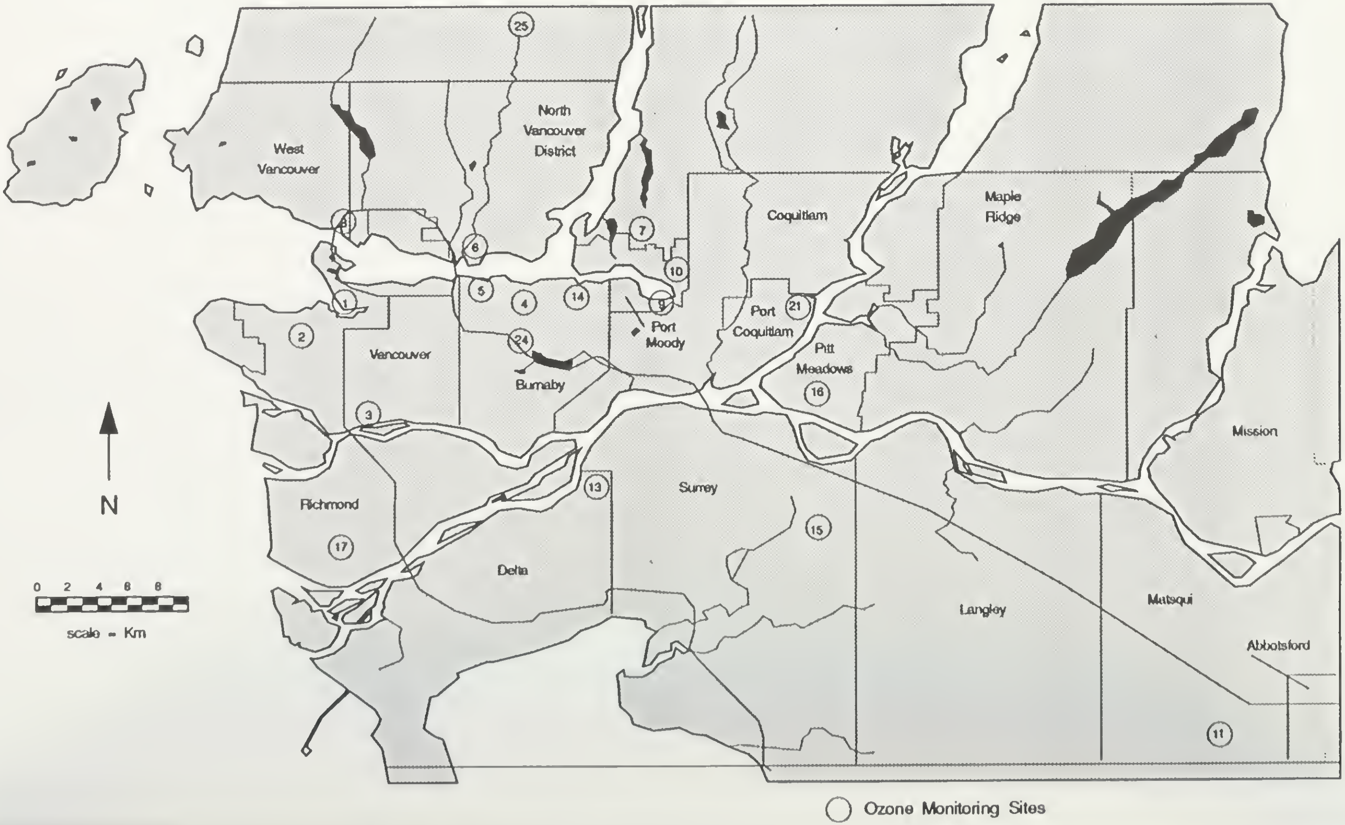
(1) The Montreal Urban Community (MUC) was the only jurisdiction found to have standards for some of the sectors in the Solvent Use Category.

(2) "Yes" means - other States or Countries have adepted or proposed standards for this sector.

APPENDIX D

AMBIENT AIR QUALITY DATA

Greater Vancouver Regional District



Maximum Ozone (ppm) and % Reduction Required to Achieve Max. Acceptable AQO (0.082 ppm)
GVRD and Lower Fraser Valley

SITE	ADDRESS	LOC	1983	1984	1985	1986	1987	1988	1989	Avg. (83-89)	% Red. Average	Avg. of 3 High Max.	%Red. 3 High Max.	Max. (83-89)	%Red. Max.
T4	Kensington Park	EAST	0.075	0.084	0.076	0.065	0.082	0.105	0.075	0.080	0%	0.090	9%	0.105	22%
T5	Confederation Park	EAST	0.077	0.089	0.094	0.095	0.085	0.105	0.094	0.091	10%	0.098	16%	0.105	22%
T7	Anmore	EAST	0.113	0.089	0.107	0.121	0.092	0.156	0.073	0.107	24%	0.130	37%	0.156	47%
T9	Rocky Point Park	EAST	0.169	0.106	0.124	0.131	0.084	0.149	0.101	0.123	34%	0.147	44%	0.169	51%
T10	Eagle Ridge	EAST	0.096	0.109	0.105	0.133	0.082	0.167	0.096	0.113	27%	0.136	40%	0.167	51%
T14	Burnaby Mountain	EAST		0.064	0.079	0.080	0.074	0.194	0.088	0.097	15%	0.118	30%	0.194	58%
T21	Port Coquitlam	EAST					0.105	0.213	0.071	0.130	37%	0.130	37%	0.213	62%
T24	Burnaby Lake	EAST				0.064	0.070	0.094	0.080	0.077	0%	0.084	2%	0.094	13%
Avg.			0.106	0.090	0.098	0.098	0.084	0.148	0.085	0.102	18%	0.117	30%	0.150	45%
T11	Abbotsford	RURAL		0.117	0.107	0.098	0.088	0.118	0.089	0.103	20%	0.114	28%	0.118	31%
T12	Chilliwack	RURAL		0.122	0.107	0.084	0.099	0.104	0.098	0.102	20%	0.111	26%	0.122	33%
T15	Surrey East	RURAL		0.116	0.110	0.072	0.084	0.159	0.078	0.103	21%	0.128	36%	0.159	48%
T16	Pitt Meadows	RURAL			0.114	0.098	0.094	0.154	0.072	0.106	23%	0.122	33%	0.154	47%
T25	Seymour Falls	RURAL	0.057	0.064	0.106	0.094	0.092	0.119	0.073	0.086	5%	0.106	23%	0.119	31%
Avg.				0.105	0.109	0.089	0.091	0.131	0.082	0.100	18%	0.116	30%	0.134	39%
T2	Kitsilano	WEST	0.101	0.075	0.082		0.069	0.084	0.083	0.082	0%	0.089	8%	0.101	19%
T3	Marpole	WEST	0.057	0.060	0.068	0.062	0.069	0.080	0.079	0.068	0%	0.072	0%	0.080	0%
T6	Second Narrows	WEST	0.063	0.093	0.070	0.045	0.054	0.069	0.075	0.067	0%	0.077	0%	0.093	12%
T8	Lions Gata	WEST	0.068	0.092		0.060	0.074	0.087	0.058	0.073	0%	0.084	3%	0.092	11%
T13	North Delta	WEST		0.053		0.059	0.054	0.081	0.065	0.062	0%	0.065	0%	0.081	0%
T17	Richmond South	WEST				0.048	0.084	0.077	0.070	0.070	0%	0.077	0%	0.084	2%
Avg.			0.072	0.075	0.073	0.055	0.067	0.080	0.072	0.070	0%	0.077	0%	0.089	7%

No. of Hours > Acceptable AQO (0.082 ppm) - GVRD and Lower Fraser Valley

SITE	ADDRESS	LOC	1983	1984	1985	1986	1987	1988	1989	Average	Avg. of 3 High Years
T4	Kensington Park	EAST	0	1	0	0	0	10	0	2	4
T5	Confederation Park	EAST	0	2	8	2	1	16	3	5	9
T7	Anmore	EAST	7	1	16	13	4	31	0	10	20
T9	Rocky Point Park	EAST	36	12	36	11	2	39	3	20	37
T10	Eagle Ridge	EAST	7	9	7	16	0	34	4	11	20
T14	Burnaby Mountain	EAST		0	0	0	1	26	2	5	9
T21	Port Coquitlam	EAST					5	27	0	11	11
T24	Burnaby Lake	EAST				0	0	1	0	0	0
Avg.			10	4	11	6	2	23	2	8	14
T11	Abbotsford	RURAL		7	13	11	3	26	9	12	17
T12	Chilliwack	RURAL		8	16	1	12	13	4	9	14
T15	Surrey East	RURAL		11	29	0	4	26	0	12	22
T16	Pitt Meadows	RURAL			9	3	1	13		7	8
T25	Seymour Falls	RURAL	0	0	10	3	3	20	0	5	11
Avg.				7	15	4	5	20	3	9	14
T2	Kitsilano	WEST	1	0	0		0	1	2	1	1
T3	Marpole	WEST	0	0	0	0	0	0	0	0	0
T6	Second Narrows	WEST	0	4	0	0	0	0	2	1	1
T8	Lions Gate	WEST	0	2		0	0	2	0	1	1
T13	North Delta	WEST		0		0	0	0	0	0	0
T17	Richmond South	WEST				0	1	0	0	0	0
Avg.			0	1	0	0	0	1	1	0	1

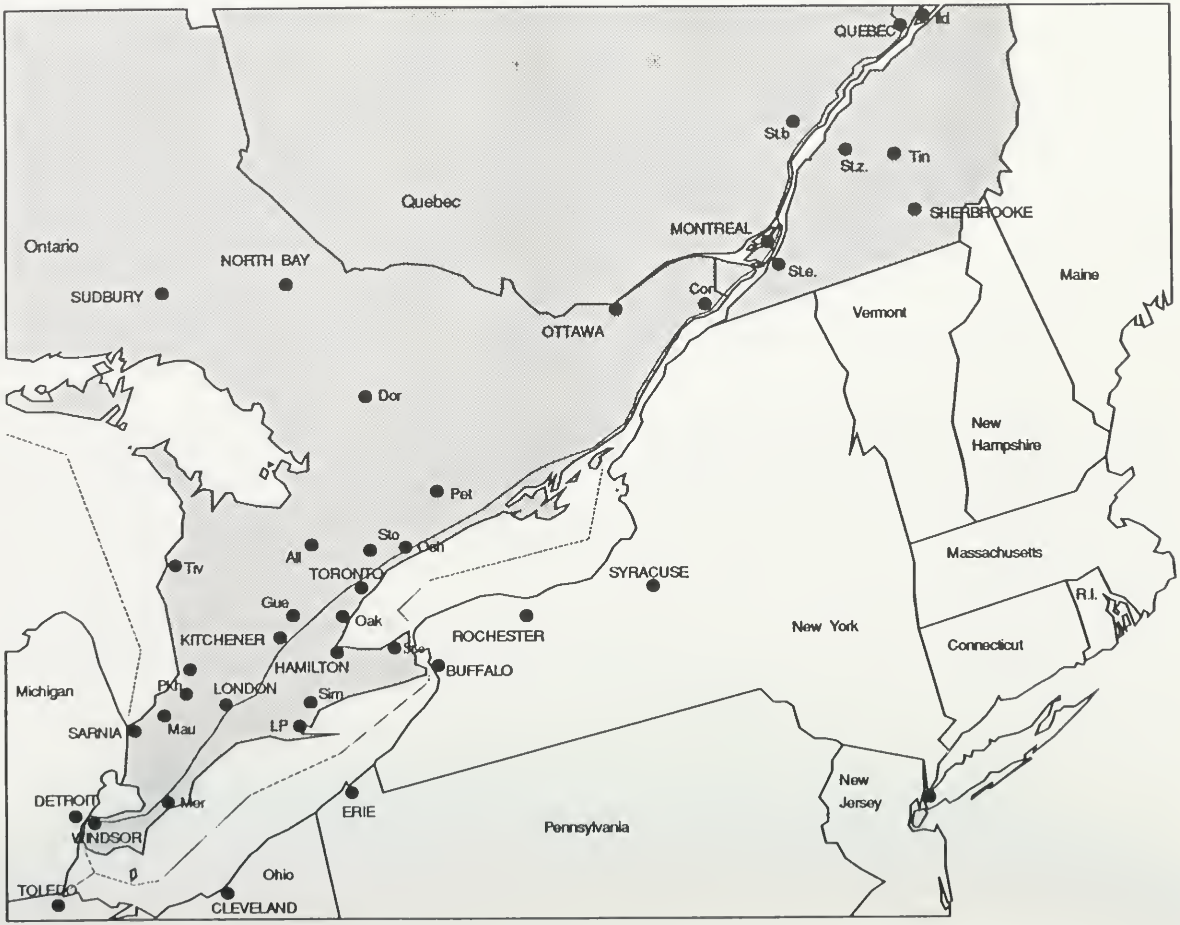
Maximum Ozone (ppm) and % Reduction Required to Achieve Max. Acceptable AQO (0.082 ppm)
N. Ontario and Prairies

Station No.	City	1983	1984	1985	1986	1987	1988	1989	Avg (83-89)	% Red. Average	Avg . of 3 High Max.	% Red. 3 High Max.	Max. (83-89)	% Red. Max
60707	Sault Ste. Marie	0.090	0.070	0.070	0.060	0.090	0.090	0.100	0.081	0%	0.090	9%	0.100	18%
60807	Thunder Bay	0.070	0.060		0.060	0.060	0.080	0.090	0.070	0%	0.080	0%	0.090	9%
70118	Winnipeg	0.080	0.080	0.080	0.070	0.070	0.090	0.100	0.081	0%	0.090	9%	0.100	18%
70119	Winnipeg	0.090	0.080	0.070	0.070	0.080	0.090	0.100	0.083	1%	0.093	12%	0.100	18%
80110	Regina	0.100	0.100	0.080		0.050	0.100	0.060	0.082	0%	0.100	18%	0.100	18%
80209	Saskatoon		0.070	0.060	0.060	0.060	0.060	0.070	0.063	0%	0.067	0%	0.070	0%
90122	Edmonton	0.080		0.070	0.080	0.090	0.080	0.070	0.078	0%	0.083	2%	0.090	9%
90130	Edmonton	0.060	0.090	0.090	0.090	0.070	0.070	0.070	0.077	0%	0.090	9%	0.090	9%
90222	Calgary	0.080	0.090	0.080	0.080	0.080	0.090	0.110	0.087	6%	0.097	15%	0.110	25%
90227	Calgary	0.070	0.070	0.070	0.070	0.060	0.070	0.070	0.069	0%	0.070	0%	0.070	0%
Average		0.080	0.079	0.074	0.071	0.071	0.082	0.084	0.077	1%	0.086	7%	0.092	12%

No. of Hours > Acceptable AQO (0.082 ppm) - N. Ontario and Prairies

Station No.	City	1983	1984	1985	1986	1987	1988	1989	Yrs of Data	Avg (83-89)	Avg 3 High Years
60707	Sault Ste. Maria	9	0	0	0	4	9	15	7	5	11
60807	Thunder Bay	0	0		0	0	0	5	6	1	2
70118	Winnipeg	0	0	0	0	0	4	7	7	2	4
70119	Winnipeg	2	1	0	0	0	1	2	7	1	2
80110	Regina	1	38	1		0	1	0	6	7	13
80209	Saskatoon		0	0	0	0	0	0	6	0	0
90122	Edmonton	2		0	1	8	1	0	6	2	3
90130	Edmonton	0	5	1	4	0	0	0	7	1	3
90222	Calgary	1	3	0	0	2	3	3	7	2	3
90227	Calgary	0	0	0	0	0	0	0	7	0	0
Average		2	5	0	1	1	2	3	7	2	4

Windsor - Quebec Ozone Monitoring Sites



Maximum Ozone (ppm) and % Reduction Required to Achieve Max. Acceptable AQO (0.082 ppm) - Ontario and Quebec

NAPS	Station No.	City	Address	U/S/R*	1983	1984	1985	1986	1987	1988
	10001	Huron Park		R	0.112	0.125	0.101	0.107	0.121	0.127
60204	12008	Windsor	467 University	U	0.135	0.143	0.116	0.104	0.110	0.159
	13021	Merlin		R	0.121	0.087	0.092	0.091	0.126	0.133
61004	14064	Sarnia	Centennial Park	U	0.136	0.125	0.110	0.114	0.170	0.131
	14118	Mandaumin		R	0.097	0.130	0.114	0.108	0.134	0.146
	14119	Thedford		R	0.118	0.130	0.127	0.121	0.139	
60901	15001	London	King/Rectory	U	0.122	0.114	0.110	0.099	0.117	0.137
	15013	Parkhill		R	0.121	0.129	0.100	0.140	0.144	0.124
	18007	Tiverton		R	0.139	0.134	0.122	0.131	0.117	0.143
	22071	Simcoe		R	0.123	0.115	0.118	0.105	0.117	0.190
	22901	Long Point		R	0.136	0.130	0.135	0.124	0.132	0.189
61501	26029	Kitchener	Edna/Frederick	U	0.108	0.090	0.105	0.116	0.094	0.118
	27056	Niagara Falls	Allendale	U						0.139
	27037	St. Catharines	North/Geneva	U	0.115	0.113	0.092	0.091		0.132
	28028	Guelph		U/S				0.102	0.104	0.117
60512	29000	Hamilton	Elgin/Kelly	U	0.111	0.095	0.096	0.088	0.105	0.137
	29105	Hamilton	Nash Rd.	U			0.104	0.096	0.111	0.128
	29114	Hamilton	Vickers Rd.	U				0.094	0.114	0.131
60417	31104	Toronto	26 Breadalbane	U	0.148	0.130	0.104	0.086	0.133	0.159
	31120	Toronto	Junction	U	0.153	0.120	0.107	0.097	0.149	0.178
60410	33003	Toronto	Lawrence/Kennedy	U	0.159	0.139	0.080	0.110	0.115	0.162
60413	35003	Etobicoke	Elmcrest Rd.	U	0.147	0.113	0.118	0.113	0.128	0.148
60403	35033	Etobicoke	Evans/Arnold	U	0.107	0.090	0.101	0.102	0.128	0.157
	44008	Burlington	Hwy 2	U	0.116	0.162	0.115	0.099	0.167	0.151
61602	44015	Oakville	Bronte Rd.	U	0.118	0.111	0.097	0.097	0.165	0.183
61701	45025	Oshawa	Ritson Rd.	U	0.158	0.085	0.115	0.112	0.137	0.185
60415	46110	Mississauga	Queensway W	U	0.153	0.111	0.104	0.103	0.141	0.177
	47035	Alliston		S	0.087	0.095	0.094	0.096	0.094	0.177
	48002	Stouffville		R/S	0.120	0.084	0.093	0.103	0.105	0.161
	49010	Dorset		R	0.101	0.089	0.080	0.089	0.098	0.117
60104	51001	Ottawa	Rideau/Wurt.	U	0.104	0.095	0.096	0.076	0.070	0.127
61201	56051	Cornwall		U	0.106	0.096	0.081	0.097	0.091	0.127
61103	59006	Peterborough		S		0.079	0.107	0.104	0.101	0.168
	75010	North Bay		S						0.109
	77203	Sudbury		S			0.117	0.104	0.089	0.113
50102		Montreal	Jardin Botanique	U	0.150	0.090	0.060	0.080		0.110
50103		Montreal	Pte. aux Trembles	U		0.100	0.160	0.110	0.100	0.130
50104		Montreal	1125 Ontario	U	0.170	0.080	0.080	0.080	0.100	0.110
50110		Montreal	Parc Pilon	U	0.120		0.090	0.100	0.120	0.160
50112		Montreal	Boul. Laurentides	U	0.120	0.080	0.100	0.080	0.100	0.130
50113		Montreal	Pie X/Cardinal	U	0.140	0.100	0.100	0.100		0.130
50116		Montreal	Verdun	U	0.130	0.080	0.090	0.130	0.120	0.120
50119		Montreal	699 Cure Poirier	U		0.100	0.110	0.090		0.180
50120		Montreal	Roxboro	U						0.130
50306		Quebec	Blvd. St. Cyrille	U	0.100	0.070	0.110	0.100	0.070	0.140
50307		Quebec	Parc Cartier Breboeuf	U		0.060	0.160	0.070	0.060	0.080
51401		Ste. Etienne		R				0.120	0.120	
51501		St. Zephirim		R					0.100	0.150
51601		Ile d'Orleans		R					0.090	0.140
51701		St. Barnabe		R					0.130	0.150
Average					0.126	0.106	0.105	0.102	0.116	0.143
No. of Sites					35	38	41	44	43	48

*U-Urban S-Suburban R-Rural

Maximum Ozone (ppm) and % Reduction Required to Achieve Max. Acceptable AQO (0.082 ppm) - Ontario and Quebec

NAPS	Station No.	City	Address	U/S/R*	1989	Yrs. of Data	Max	% Reduction (Maximum)	Average (83-89)
	10001	Huron Park		R	0.103	7	0.127	35%	0.114
60204	12008	Windsor	467 University	U	0.136	7	0.159	48%	0.129
	13021	Merlin		R	0.108	7	0.133	38%	0.108
61004	14064	Sarnia	Centennial Park	U	0.157	7	0.170	52%	0.135
	14118	Mandaumin		R	0.125	7	0.146	44%	0.122
	14119	Thedford		R		5	0.139	41%	0.127
60901	15001	London	King/Rectory	U	0.109	7	0.137	40%	0.115
	15013	Parkhill		R	0.115	7	0.144	43%	0.125
	18007	Tiverton		R	0.128	7	0.143	43%	0.131
	22071	Simcoe		R	0.093	7	0.190	57%	0.123
	22901	Long Point		R	0.135	7	0.189	57%	0.140
61501	26029	Kitchener	Edna/Frederick	U	0.098	7	0.118	31%	0.104
	27056	Niagara Falls	Allendale	U	0.109	2	0.139	41%	0.124
	27037	St. Catharines	North/Geneva	U	0.105	6	0.132	38%	0.108
	28028	Guelph		U/S	0.103	4	0.117	30%	0.107
60512	29000	Hamilton	Elgin/Kelly	U	0.127	7	0.137	40%	0.108
	29105	Hamilton	Nash Rd.	U	0.106	5	0.128	36%	0.109
	29114	Hamilton	Vickers Rd.	U	0.099	4	0.131	37%	0.110
60417	31104	Toronto	26 Breadalbane	U	0.139	7	0.159	48%	0.128
	31120	Toronto	Junction	U	0.161	7	0.178	54%	0.138
60410	33003	Toronto	Lawrence/Kennedy	U	0.156	7	0.162	49%	0.132
60413	35003	Etobicoke	Elmcrest Rd.	U	0.121	7	0.148	45%	0.127
60403	35033	Etobicoke	Evans/Arnold	U	0.094	7	0.157	48%	0.111
	44008	Burlington	Hwy 2	U	0.158	7	0.167	51%	0.138
61602	44015	Oakville	Bronte Rd.	U	0.132	7	0.183	55%	0.129
61701	45025	Oshawa	Ritson Rd.	U	0.118	7	0.185	56%	0.130
60415	46110	Mississauga	Queensway W	U	0.139	7	0.177	54%	0.133
	47035	Alliston		S	0.097	7	0.177	54%	0.106
	48002	Stouffville		R/S	0.125	7	0.161	49%	0.113
	49010	Dorset		R		6	0.117	30%	0.096
60104	51001	Ottawa	Rideau/Wurt.	U	0.093	7	0.127	35%	0.094
61201	56051	Cornwall		U	0.083	7	0.127	35%	0.097
61103	59006	Peterborough		S	0.104	6	0.168	51%	0.111
	75010	North Bay		S	0.096	2	0.109	25%	0.103
	77203	Sudbury		S	0.095	5	0.117	30%	0.104
50102		Montreal	Jardin Botanique	U	0.130	6	0.150	45%	0.103
50103		Montreal	Pte. aux Trembles	U	0.120	6	0.160	49%	0.120
50104		Montreal	1125 Ontario	U	0.120	7	0.170	52%	0.106
50110		Montreal	Parc Pilon	U	0.090	6	0.160	49%	0.113
50112		Montreal	Boul. Laurentides	U	0.090	7	0.130	37%	0.100
50113		Montreal	Pie X/Cardinal	U	0.110	6	0.140	41%	0.113
50116		Montreal	Verdun	U	0.110	7	0.130	37%	0.111
50119		Montreal	699 Cure Poirier	U	0.130	5	0.180	54%	0.122
50120		Montreal	Roxboro	U	0.120	2	0.130	37%	0.125
50306		Quebec	Blvd. St. Cyrille	U	0.090	7	0.140	41%	0.097
50307		Quebec	Parc Cartier Breboeuf	U	0.070	6	0.160	49%	0.083
51401		Ste. Etienne		R		2	0.120	32%	0.120
51501		St. Zephirim		R		2	0.150	45%	0.125
51601		Ile d'Orleans		R		2	0.140	41%	0.115
51701		St. Barnabe		R		2	0.150	45%	0.140
Average					0.115		0.143	42%	0.116
No. of Sites					44		50		

*U-Urban S-Suburban R-Rural

Maximum Ozone (ppm) and % Reduction Required to Achieve Max. Acceptable AQO (0.082 ppm) - Ontario and Quebec

NAPS	Station No.	City	Address	U/S/R*	% Reduction (Avg.)		Avg of 3 High Yrs	% Red (Avg 3 High Yrs.)
	10001	Huron Park		R	28%		0.124	34%
60204	12008	Windsor	467 University	U	36%		0.146	44%
	13021	Merlin		R	24%		0.127	35%
61004	14064	Sarnia	Centennial Park	U	39%		0.154	47%
	14118	Mandaumin		R	33%		0.137	40%
	14119	Thedford		R	35%		0.132	38%
60901	15001	London	King/Rectory	U	29%		0.125	35%
	15013	Parkhill		R	34%		0.138	40%
	18007	Tiverton		R	37%		0.139	41%
	22071	Simcoe		R	33%		0.143	43%
	22901	Long Point		R	41%		0.153	47%
61501	26029	Kitchener	Edna/Frederick	U	21%		0.113	27%
	27056	Niagara Falls	Allendale	U	34%			
	27037	St. Catharines	North/Geneva	U	24%		0.112	27%
	28028	Guelph		U/S	23%		0.108	24%
60512	29000	Hamilton	Elgin/Kelly	U	24%		0.125	34%
	29105	Hamilton	Nash Rd.	U	25%		0.115	29%
	29114	Hamilton	Vickers Rd.	U	25%		0.115	28%
60417	31104	Toronto	26 Breadalbane	U	36%		0.149	45%
	31120	Toronto	Junction	U	41%		0.164	50%
60410	33003	Toronto	Lawrence/Kennedy	U	38%		0.159	48%
60413	35003	Etobicoke	Elmcrest Rd.	U	35%		0.141	42%
60403	35033	Etobicoke	Evans/Arnold	U	26%		0.131	37%
	44008	Burlington	Hwy 2	U	41%		0.162	49%
61602	44015	Oakville	Bronte Rd.	U	36%		0.155	47%
61701	45025	Oshawa	Ritson Rd.	U	37%		0.160	49%
60415	46110	Mississauga	Queensway W	U	38%		0.157	48%
	47035	Alliston		S	22%		0.123	34%
	48002	Stouffville		R/S	27%		0.135	39%
	49010	Dorset		R	14%		0.101	19%
60104	51001	Ottawa	Rideau/Wurt.	U	13%		0.109	25%
61201	56051	Cornwall		U	16%		0.102	20%
61103	59006	Peterborough		S	26%		0.126	35%
	75010	North Bay		S	20%			
	77203	Sudbury		S	21%		0.111	26%
50102		Montreal	Jardin Botanique	U	21%		0.130	37%
50103		Montreal	Pte. aux Trembles	U	32%		0.137	40%
50104		Montreal	1125 Ontario	U	22%		0.110	25%
50110		Montreal	Parc Pilon	U	28%		0.123	34%
50112		Montreal	Boul. Laurentides	U	18%		0.117	30%
50113		Montreal	Pie X/Cardinal	U	28%		0.127	35%
50116		Montreal	Verdun	U	26%		0.127	35%
50119		Montreal	699 Cure Poirier	U	33%		0.140	41%
50120		Montreal	Roxboro	U	34%			
50306		Quebec	Blvd. St. Cyrille	U	16%		0.117	30%
50307		Quebec	Parc Cartier Breboeuf	U	2%		0.103	21%
51401		Ste. Etienne		R	32%			
51501		St. Zephirim		R	34%			
51601		Ile d'Orleans		R	29%			
51701		St. Barnabe		R	41%			
Average					29%		0.131	36%
No. of Sites								

*U-Urban S-Suburban R-Rural

No. of Hours > Acceptable AQO (0.082 ppm) - Ontario and Quebec

NAPS	Station No.	City	Address	R/S/U*	1989	Avg. 3 High Yrs	Average (83-89)	Yrs of Data
	10001	Huron Park+		R	54	141	90	7
60204	12008	Windsor	467 University	U	45	159	101	7
	13021	Merlin+		R	77	178	88	7
61004	14064	Sarnia	Centennial Park	U	68	107	73	7
	14118	Mandaumin+		R	21	167	86	7
	14119	Thedford+		R		84	62	5
60901	15001	London	King/Rectory	U	46	85	56	7
	15013	Parkhill+		R	61	142	89	7
	18007	Tiverton+		R	86	195	119	7
	22071	Simcoe+		R	42	219	135	7
	22901	Long Point+		R	257	331	233	7
61501	26029	Kitchener	Edna/Frederick	U	11	87	47	7
	27037	St. Catharines+	North/Geneva	U	10	86	50	6
	27056	Niagara Falls+	Allendale Ave.	U	77		142	2
	28028	Guelph+	Exhibition St.	U/S	37	83	69	4
60512	29000	Hamilton	Elgin/Kelly	U	55	87	45	7
	29105	Hamilton+	Nash Rd.	U	37	68	48	5
	29114	Hamilton+	Vickers Rd.	U	31	92	61	5
60417	31104	Toronto	26 Breadalbane	U	23	80	49	7
	31120	Toronto+	Junction	U	77	104	70	7
60410	33003	Toronto	Lawrence/Kennedy	U	52	79	50	7
60413	35003	Etobicoke	Elmcrest Rd.	U	35	116	75	7
60403	35033	Etobicoke	Evans/Arnold	U	5	49	29	7
	44008	Burlington+	Hwy 2	U	106	95	60	7
61602	44015	Oakville	Bronte Rd.	U	97	101	55	7
61701	45025	Oshawa	Ritson Rd.	U	74	104	60	7
60415	46110	Mississauga	Queensway W	U	98	81	44	7
	47035	Alliston+		S	13	47	25	7
	48002	Stouffville+		R/S	106	96	51	6
	49010	Dorset+		R	58	73	38	7
60104	51001	Ottawa	Rideau/Wurt.	U	6	26	12	7
61201	56051	Cornwall		U	1	37	25	7
61103	59006	Peterborough		S	32	48	31	6
	75010	North Bay+		S	36		78	2
	77203	Sudbury+	Science North	S	15	50	33	5
50102		Montreal	Jardin Botanique	U	28	16	9	6
50103		Montreal	Pte. aux Trembles	U	20	25	18	6
50104		Montreal	1125 Ontario	U	13	31	13	7
50110		Montreal	Parc Pilon	U	1	60	27	7
50112		Montreal	Boul. Laurentides	U	6	46	24	6
50113		Montreal	Pie X/Cardinal	U	13	63	36	6
50116		Montreal	Verdun	U	15	49	24	7
50119		Montreal	699 Cure Poirier	U	28	69	39	6
50120		Montreal	Roxboro	U	13		42	2
50306		Quebec	Blvd. St. Cyrille	U	5	16	10	6
50307		Quebec	Parc Cartier Breboeuf	U	0	11	5	6
51401		Ste. Etienne		R			12	2
51501		St. Zephirim		R			79	2
51601		Ile d'Orleans		R			1	1
51701		St. Barnabe		R			37	2
Average					44	90	55	

+ Hrs > 82 ppb Stat. NA - Hrs. > 80 ppb used

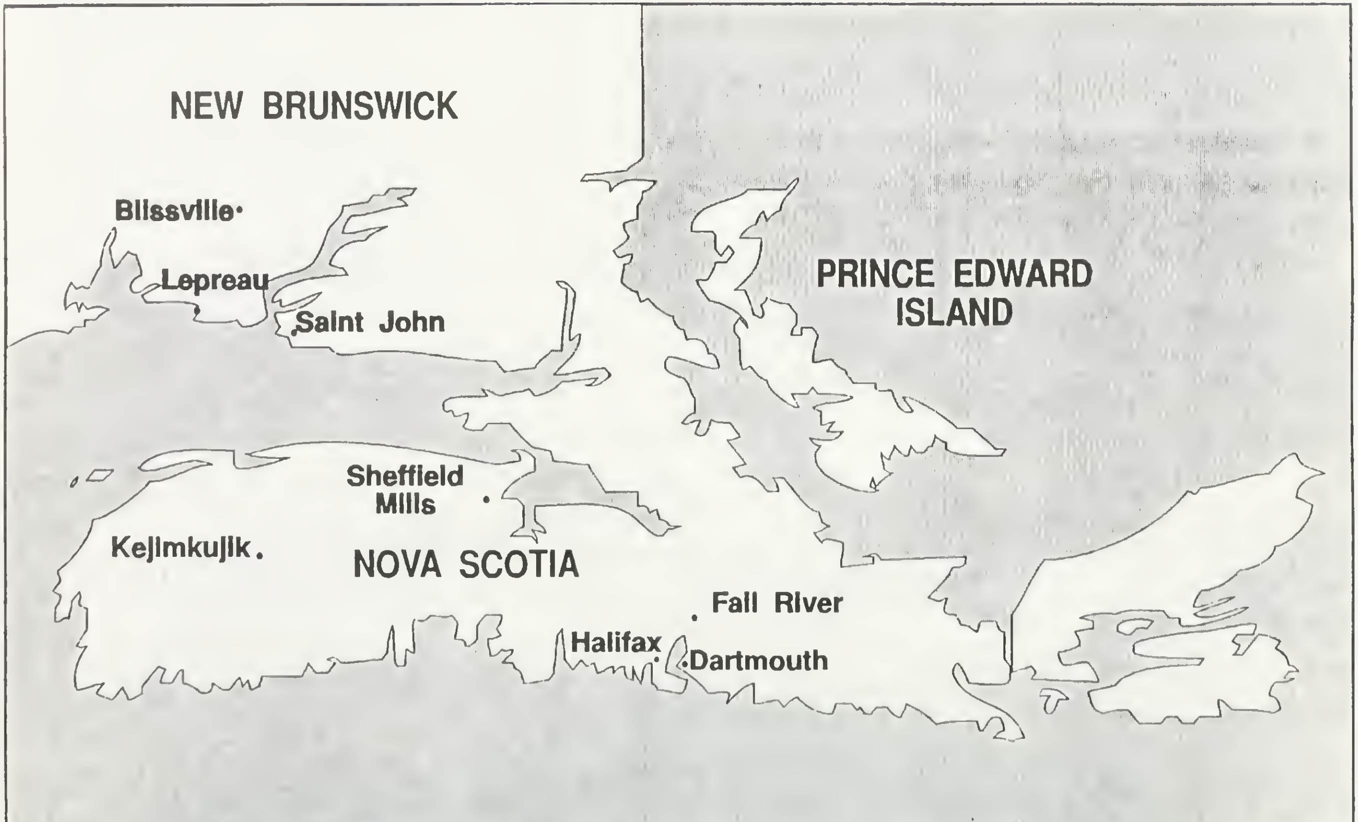
*U-Urban S-Suburban R-Rural

No. of Hours > Acceptable AQO (0.082 ppm) - Ontario and Quebec

NAPS	Station No.	City	Address	R/S/U*	1983	1984	1985	1986	1987	1988
	10001	Huron Park+		R	107	68	38	44	89	228
60204	12008	Windsor	467 University	U	116	139	77	39	70	223
	13021	Merlin+		R	57	5	17	5	95	362
61004	14064	Sarnia	Centennial Park	U	116	80	47	30	44	125
	14118	Mandaumin+		R	16	128	25	41	133	239
	14119	Thedford+		R	16	79	92	44	80	
60901	15001	London	King/Rectory	U	72	24	31	14	34	174
	15013	Parkhill+		R	61	63	16	57	158	204
	18007	Tiverton+		R	87	42	86	31	167	331
	22071	Simcoe+		R	182	122	71	53	119	354
	22901	Long Point+		R	169	152	183	165	139	566
61501	26029	Kitchener	Edna/Frederick	U	57	6	27	33	21	172
	27037	St. Catharines+	North/Geneva	U	116	19	19	11		123
	27056	Niagara Falls+	Allendale Ave.	U						207
	28028	Guelph+	Exhibition St.	U/S				24	75	138
60512	29000	Hamilton	Elgin/Kelly	U	61	7	17	5	24	144
	29105	Hamilton+	Nash Rd.	U			23	11	69	99
	29114	Hamilton+	Vickers Rd.	U			0	34	85	156
60417	31104	Toronto	26 Breadalbane	U	79	45	27	11	51	110
	31120	Toronto+	Junction	U	118	50	18	36	81	112
60410	33003	Toronto	Lawrence/Kennedy	U	74	17	0	46	56	106
60413	35003	Etobicoke	Elmcrest Rd.	U	119	64	33	75	43	154
60403	35033	Etobicoke	Evans/Arnold	U	29	7	14	38	40	68
	44008	Burlington+	Hwy 2	U	55	124	19	46	31	38
61602	44015	Oakville	Bronte Rd.	U	27	14	12	31	66	141
61701	45025	Oshawa	Ritson Rd.	U	101	2	42	20	41	138
60415	46110	Mississauga	Queensway W	U	38	10	13	17	25	108
	47035	Alliston+		S	3	29	12	7	14	99
	48002	Stouffville+		R/S		2	8	7	30	153
	49010	Dorset+		R	20	20	0	8	41	121
60104	51001	Ottawa	Rideau/Wurt.	U	14	7	1	0	0	57
61201	56051	Cornwall		U	47	19	1	16	11	77
61103	59006	Peterborough		S		0	47	19	20	66
	75010	North Bay+		S						119
	77203	Sudbury+	Science North	S			45	8	5	91
50102		Montreal	Jardin Botanique	U	10	10	0	0		6
50103		Montreal	Pte. aux Trembles	U		2	24	27	12	24
50104		Montreal	1125 Ontario	U	28	0	0	0	2	51
50110		Montreal	Parc Pilon	U	17	0	2	8	20	142
50112		Montreal	Boul. Laurentides	U	44	0	3		3	89
50113		Montreal	Pie X/Cardinal	U	68	8	22	7		99
50116		Montreal	Verdun	U	36	0	3	6	15	95
50119		Montreal	699 Cure Poirier	U		20	23	2	1	157
50120		Montreal	Roxboro	U						70
50306		Quebec	Blvd. St. Cyrille	U	11	0	24	13		5
50307		Quebec	Parc Cartier Breboeuf	U		0	29	0	3	0
51401		Ste. Etienne		R				6	18	
51501		St. Zephirim		R					13	144
51601		Ile d'Orleans		R					1	
51701		St. Barnabe		R					23	50
Average					64	35	28	25	48	139

+ Hrs > 82 ppb Stat. NA - Hrs. > 80 ppb used

*U-Urban S-Suburban R-Rural



OZONE MONITORING SITES
ATLANTIC PROVINCES - 1988

Maximum Ozone and % Reduction Required to Achieve Max. Acceptable AQO (0.082 ppm) - Atlantic

Station No.	City	Address	U/R *	1983	1984	1985	1986	1987	1988	Avg. (83-88)	% Red. (83-88)	Avg. (86-88)	% Red. (86-88)	Max. (86-88)	% Red. Max.
30117	Halifax	Bedford	U	0.080	0.080	0.060		0.050	0.080	0.070	0%	0.065	0%	0.080	0%
30115	Halifax	Shearwater	U	0.070	0.050	0.070		0.100		0.073	0%	0.100	18%	0.100	18%
40202	Saint John	Post Office	U	0.080	0.160	0.090	0.080	0.100	0.100	0.102	19%	0.093	12%	0.100	18%
40203	Saint John	Forest Hill	U	0.110	0.160	0.160	0.080		0.100	0.122	33%	0.090	9%	0.100	18%
30601	Fall River		R				0.110	0.100	0.090	0.100	18%	0.100	18%	0.110	25%
	Sheffield Mills		R				0.100	0.108		0.104	21%	0.104	21%	0.108	24%
	Lepreau		R				0.080	0.084	0.113	0.092	11%	0.092	11%	0.113	27%
	Blissville		R					0.104	0.100	0.102	20%	0.102	20%	0.104	21%
30501	Kejimkujic		R			0.080	0.080	0.110	0.150	0.105	22%	0.113	28%	0.150	45%
Average				0.085	0.113	0.092	0.088	0.095	0.105	0.097	16%	0.096	15%	0.105	22%

* U-Urban R-Rural ▨ - Suspect Data

No. of Hours > Acceptable AQO (0.082 ppm) - Atlantic

Station No.	City	Address	U/R *	1983	1984	1985	1986	1987	1988	Yrs. of Data	Avg. (83-88)	Avg. (86-88)
30117	Halifax	Bedford	U	0	1	0		1	0	5	0	1
30115	Halifax	Shearwater	U	0	0	0	3	3	0	6	1	2
40202	Saint John	Post Office	U	2	116	5	3	32	37	6	33	24
40203	Saint John	Forest Hill	U	8	352	162	3		41	5	113	22
30601	Fall River		R				3	16	7	3	9	9
	Sheffield Mills		R				6	15		2	11	8
	Lepreau		R				2	7	52	3	20	20
	Blissvilla		R					16	21	2	19	19
30501	Kejimkujic		R			1	1	5	61	4	17	22
Average				3	117	34	3	12	27		25	14